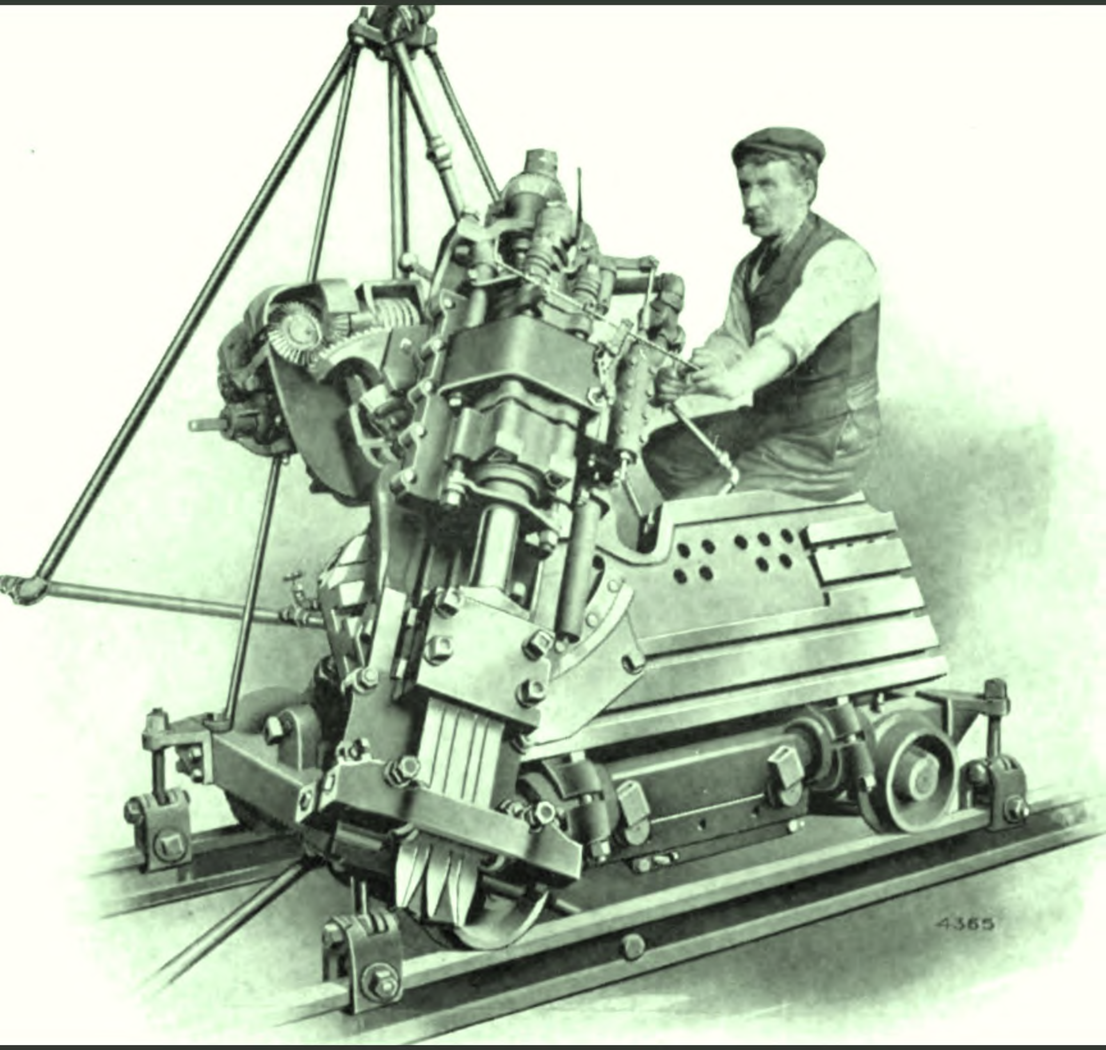


Ingersoll-Rand products

Ingersoll-Rand Company

INGERSOLL-RAND PRODUCTS

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 9007 August, 1910

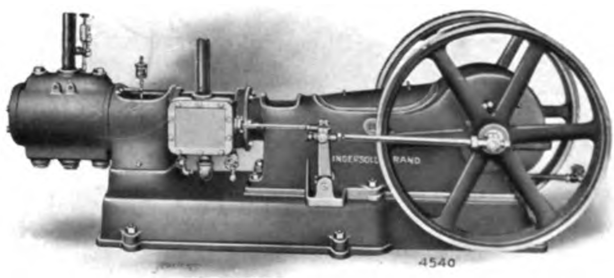
THE history of compressed air as a commercial factor in the industrial transmission of power dates from 1871. In that year two of the pioneer concerns, later united in the Companies now comprised in the Ingersoll-Rand Company, were established. Since then the Company has been identified with every important advance in the science. The history of the Ingersoll-Rand Company is, therefore, coincident with that of compressed air.

Starting with the small shops in New York City, the Company's business has grown to demand the present five plants, one of which, at Phillipsburg, N. J., is the largest shop in the world devoted exclusively to the manufacture of compressed air machinery. The output of these shops to date aggregates more than a million horse-power in air compressors, with other products in proportion.

This business has been built entirely on the solid foundation of QUALITY. The unvarying policy of the Company has been to safeguard the interests of the purchaser by furnishing only machines which represent the best possible value. Under this policy the Company's business has grown to be the largest in this line in the world.

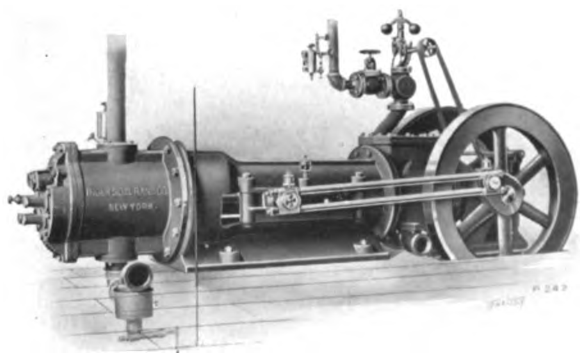
The following pages will indicate the extent and diversity of the line of Ingersoll-Rand products. Every device here presented is a QUALITY MACHINE. Every one is the result of the best engineering judgment, the largest facilities and the widest experience applied to the solution of a particular problem in some of the world's great industries. Every one represents the most advanced design, the best materials and the most perfect methods of manufacture. Every one has to its credit a record of practical success in everyday service as a guarantee of its profit-earning possibilities. Separate pamphlets describing most of these machines in detail may be had on request, and are indicated by number in the section devoted to each product

Straight Line Steam Driven Compressors



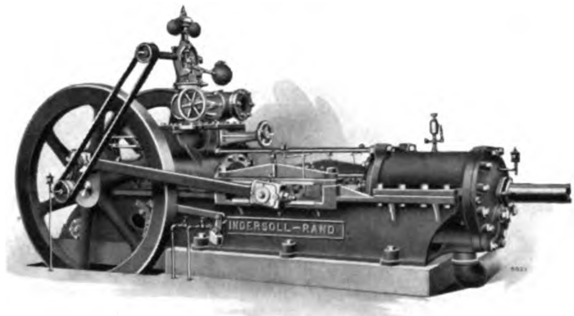
Class "NF-1"

Every up-to-date improvement is a feature of Class "NF-1" compressors: dust-proof; enclosed construction; unusual simplicity; automatic splash lubrication; high speed and large capacity with minimum dimensions. "Direct Lift" inlet valves are used on the smaller sizes; "Hurricane-Inlet" on the larger ones; "Cushioned Direct Lift" discharge valves on all sizes. Capacities in eleven sizes range from 96 to 620 cubic feet per minute; air pressure 15 to 100 pounds. See Pamphlet 3009.



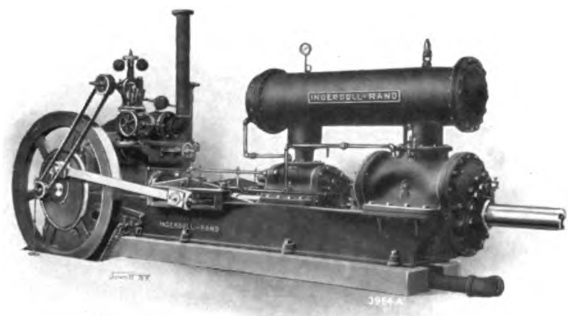
Class "RC-1"

Simple, plain, rugged in construction and of good economy — this briefly describes the Class "RC-1." It is moderate in price, reasonable in cost of installation and operation, durable and efficient under hard service, and readily managed by the average attendant. Twelve sizes in three strokes give capacities of 100 to 630 cubic feet per minute, for pressures of 15 to 100 pounds.



Class "A-1"

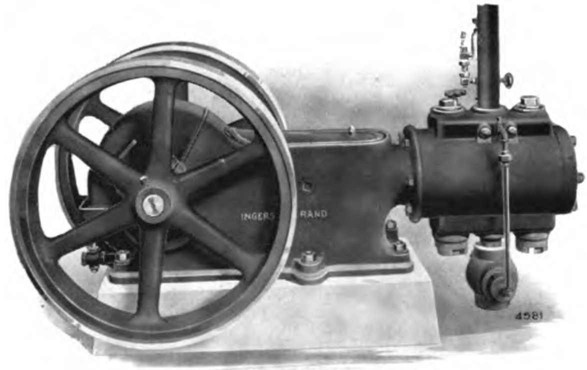
This is the "standard" single stage straight line compressor — the pioneer type, steadily improved and today "up-to-the-minute" in its class. It is a splendid example of rugged simplicity and "all-around" economy. "Hurricane-Inlet" and "Cushioned Direct Lift" discharge valves are features of the Class "A-1." There are twenty-seven sizes in this type of compressor, for pressures of 10 to 100 pounds, and capacities of 285 to 1350 cubic feet per minute. See Pamphlet 3002.



Class "AA-2"

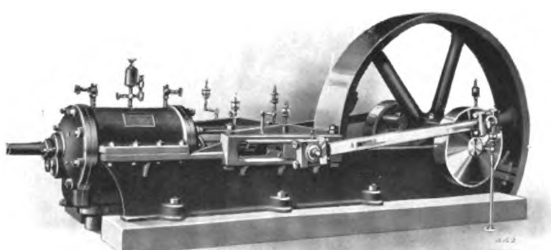
Here the steam valves are of balanced adjustable cut-off type. The air end is of the highest type of two stage construction, with a very large intercooler and completely jacketed cylinders. The "AA-2" combines compound economy with the simplicity, compactness and "unit" quality of the plain, single stage, straight line type. Air pressure delivered is 90 to 110 pounds and capacities range from 690 to 2180 cubic feet per minute, in the six standard sizes. See Pamphlet 3003

Straight Line Power Driven Compressors



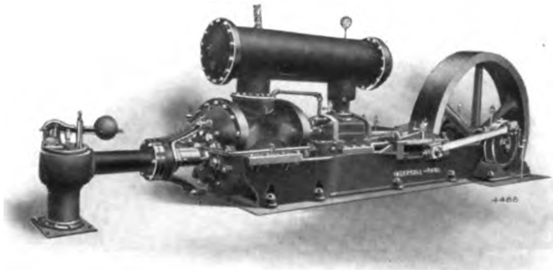
Class "NE-1"

The very latest thing in small power driven compressors is here represented, new in every detail. Enclosed, dust-proof construction; splash lubrication; unexampled simplicity; high speed and large capacity: — these are a few distinguishing features. "Hurricane-Inlet" valves are on large sizes; "Direct Lift" inlet on the small ones; "Cushioned Direct Lift" discharge valves on all. Four different strokes and fourteen sizes afford capacities of 40 to 630 cubic feet per minute; pressures 15 to 100 pounds. See Pamphlet 3110.



Class "B-1"

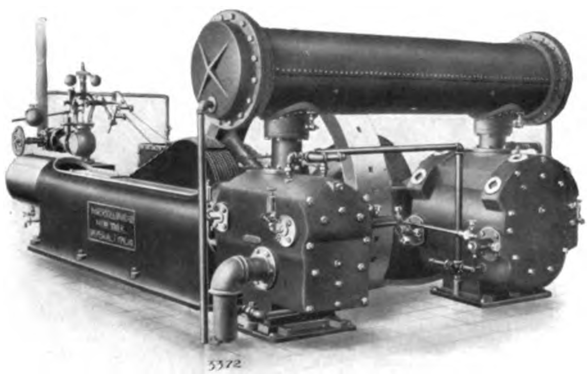
The "B-1" is a power driven modification of the Class "A-1." It is a plain, sturdy compressor designed for "all-around" duty where good economy and satisfactory performance in a simple type are desirable. It is built in three different strokes and eleven sizes, giving capacities of 180 to 920 cubic feet per minute for pressures of 20 to 100 pounds.



Class "BB-2"

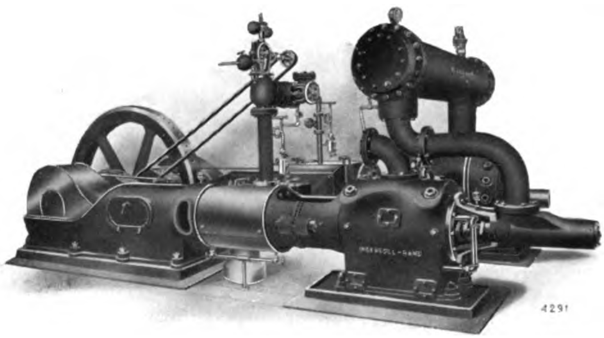
The "AA-2" steam driven type is here developed into a two stage straight line power driven compressor of distinctive character. All good straight line features are a part of it. In the air end, identical with that of the "AA-2," every element of compound economy is embodied. Six sizes have capacities of 690 to 2170 cubic feet per minute, for pressures of 90 to 110 pounds. See Pamphlet 3004 (in preparation).

Duplex Steam Driven Compressors



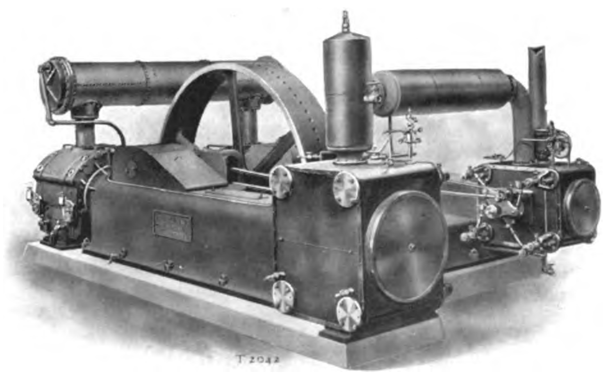
Imperial "X"

This is a duplex type of a distinct "unit" quality. Large sizes have Meyer cut-off steam valves; small sizes, plain slide valves. "Imperial Corliss" inlet and "Imperial Direct Lift" discharge valves are used on all. Enclosed construction provides for an automatic "flood" lubrication system. Capacities in simple or compound steam and air types—forty sizes—range from 120 to 4760 cubic feet per minute, for all ordinary pressures. See Pamphlet 3111.



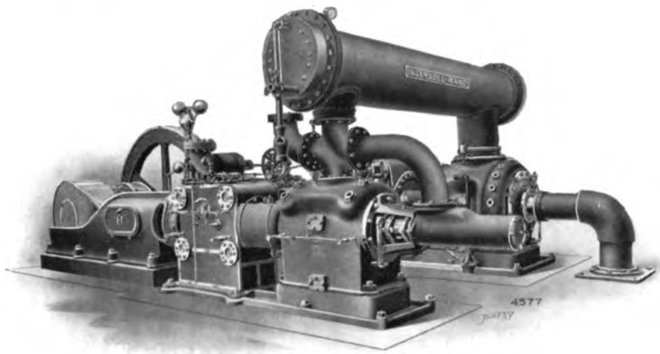
Class "O"

In this type the Meyer valve steam driven heavy duty duplex compressor is seen in its latest development. Air cylinders have "Hurricane-Inlet" and "Cushioned Direct Lift" discharge valves. Enclosed, dust-proof construction, flood lubrication, high speed and large capacity are other features. Steam and air ends may be simple or compound. There are fifty-four sizes; capacities 520 to 5190 cubic feet; pressures 15 to 125 pounds. See Pamphlet 3006.



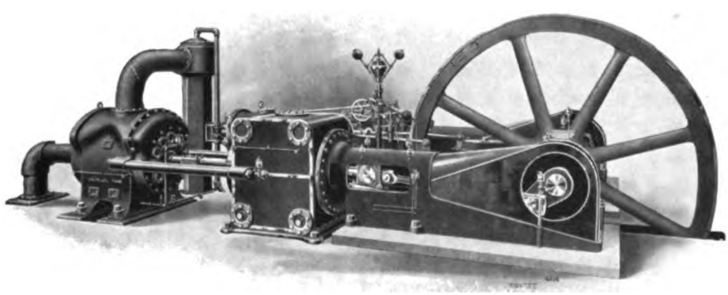
Imperial "XC"

Another splendid "Imperial" type is the "XC," with Corliss steam valves designed for high speed operation. The steam economy is practically the same as that of the standard Corliss with drop release. In other construction details the Imperial "XC" is identical with the Imperial "X" Meyer type. From 1310 to 3765 cubic feet per minute are the capacities, in twelve sizes; compound or simple steam and air ends can be had. See Pamphlet 3013.



Class "OC"

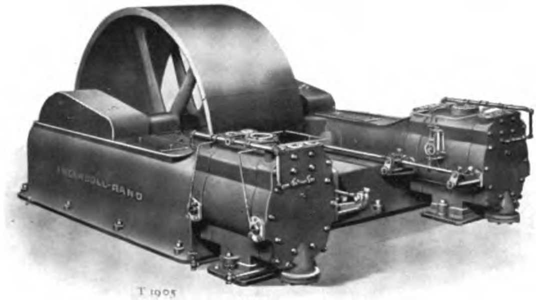
A splendid high duty compressor is here illustrated — an entirely new machine. Except for the steam cylinders, it is identical with the Class "O" Meyer type. But the "OC" has the very finest Corliss steam gear, with drop release and automatic cut-off regulation. Forty sizes are offered, simple and compound steam and air, giving capacities of 1410 to 8030 cubic feet per minute; strokes 24 to 36 inches. See Pamphlet 3023.



Class "CH"

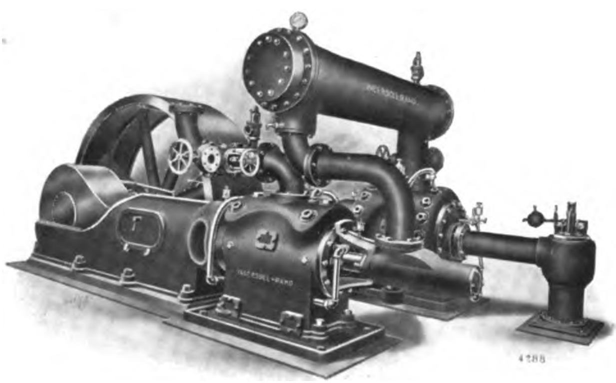
The Class "CH" Corliss is the "thoroughbred" of the compressor family. It has been designed to give the very highest possible economy in air or gas compression. Not a single feature has been neglected which would measurably contribute toward high efficiency and the best performance. Every "CH" compressor is specially designed to meet given conditions, so that no range of standard capacities can be here given. But all demands can be met in this type. See Pamphlet 3005 (in preparation).

Duplex Belt Driven Compressors



Imperial "XB"

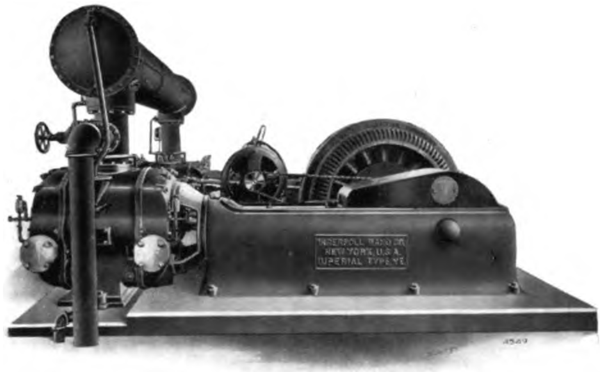
The distinctive design of the "Imperial" type is here developed in a power driven unit for belt or rope drive. The air end may be simple or compound. Inlet valves are of the "Imperial Corliss" type and discharge valves are of "Imperial Direct Lift" pattern. There are sixty-seven sizes, for all possible conditions, in capacities of 120 to 4760 cubic feet per minute, for pressures of 15 to 100 pounds. See Pamphlet 3112.



Class "PB"

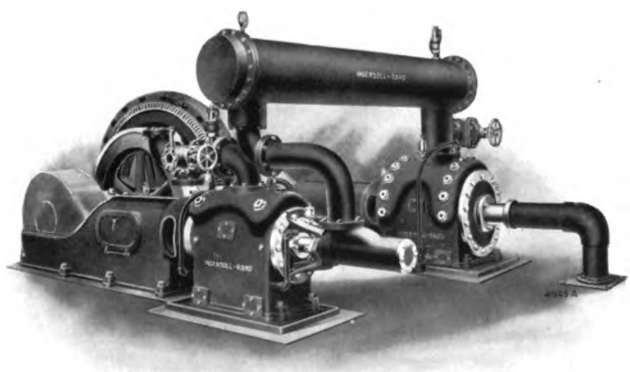
Standardization is one of the strong features of Ingersoll-Rand Compressors. The Class "PB" is the power driven counterpart, for belt or rope drive, of the Class "O" and "OC" steam driven. All the standard features of the two latter types, so far as general design and air end are concerned, are retained. Capacities range from 700 to 5200 cubic feet per minute, for pressures of 70 to 125 pounds; forty-two sizes. See Pamphlet 3007 (in preparation).

Duplex Electric Driven Compressors



Imperial "XE"

The "XE" reveals the superior Imperial type modified for direct shaft drive by electric motor. The air end has "Imperial Corliss" inlet and "Imperial Direct Lift" discharge valves. All electrical and pneumatic conditions can be met, but for the best results each Imperial "XE" is specially designed, so that no standard ratings are here given. See Pamphlet 3014 (in preparation).



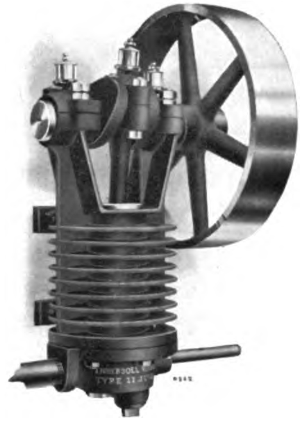
Class "PE"

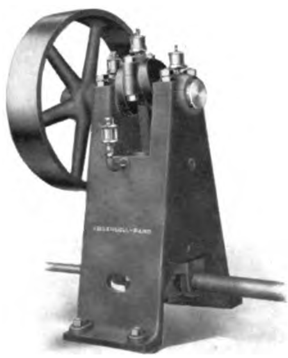
The Class "PE" is a direct-connected electrical unit with "Hurricane-Inlet" and "Cushioned Direct Lift" discharge valves. Its heavy construction and general design are a guarantee of its rugged endurance. Forty-two sizes afford capacities of 800 to 5700 cubic feet, for pressures of 70 to 125 pounds. See Pamphlet 3008 (in preparation).

Vertical Power Driven Compressors

"Imperial Baby"

This is indeed the "Baby" of the Ingersoll-Rand line, so far as size is concerned, but just as carefully designed and built as the largest duplex. It is a single-cylinder, single-acting, air-cooled type, with a capacity of 8 cubic feet per minute, for pressures of 60 to 100 pounds.



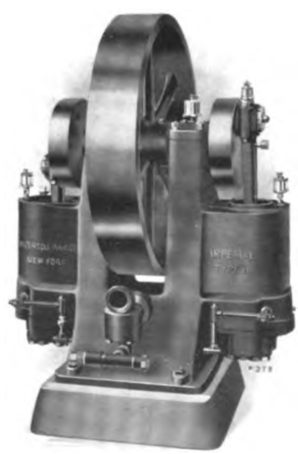


"Imperial Junior"

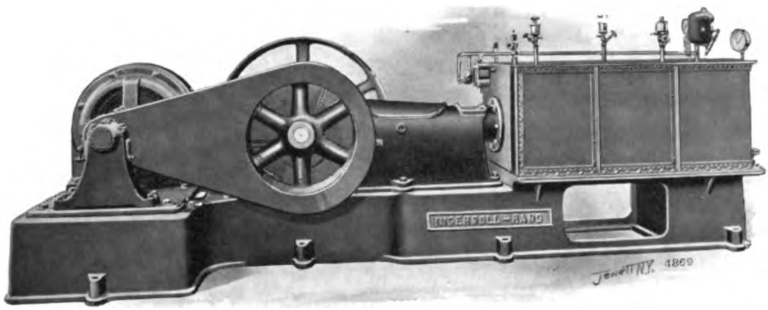
The "Junior" has the same capacity as the "Baby" and the same pressure rating. It differs only in having a water-cooled cylinder. Both the "Junior" and the "Baby" have been developed into some very compact motor-driven units where a small capacity only is desired.

"Imperial XI"

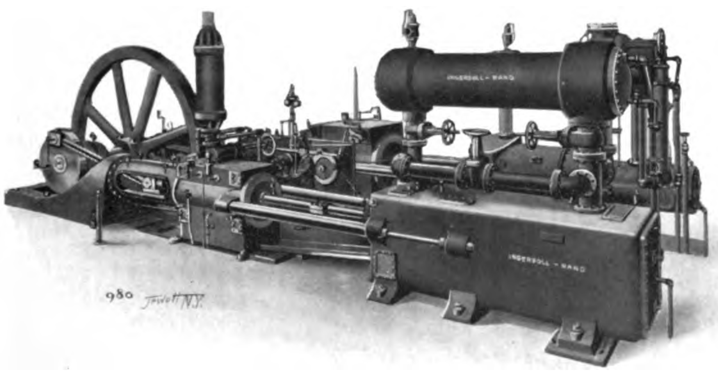
Vertical, duplex or compound single-acting, jacketed air cylinders distinguish the Imperial "XI." It has been a most popular type where compactness and simplicity are essential. Special motor-driven units can be furnished. There are four standard sizes, in two strokes, giving capacities of 16 to 88 cubic feet, for pressures of 15 to 100 pounds.



High Pressure Compressors



No builder has given so close attention to the problems of high pressure air and gas compression as the Ingersoll-Rand Company. The result is that no high pressure compressors on the market have so many valuable improvements, are so well designed and built, or give such uniform satisfaction as Ingersoll-Rand types. They are as reliable and as completely standardized as the Company's standard types for ordinary pressures.

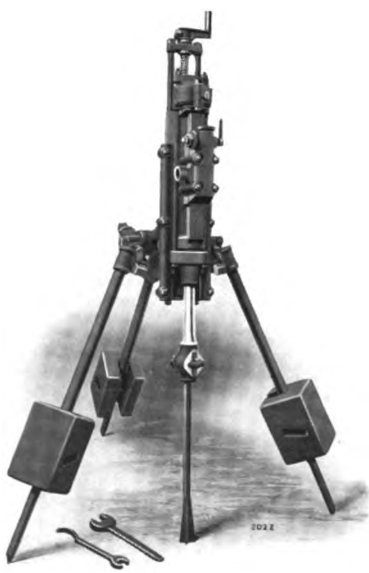


Ingersoll-Rand high pressure compressors are modifications of some of the standard types, and are offered in both straight line and duplex patterns. Unsurpassed valve movements and complete cooling are features contributing to the economy of these machines. They can be supplied in two, three and four stage types, in a wide range of capacities, and for pressures up to 3000 pounds. Quotations will be made upon receipt of full details as to conditions. See Pamphlet 3021 (in preparation).

Rock Drills

The "Sergeant"

The distinguishing feature of the "Sergeant" drill is its valve movement — a combination of the independent air-thrown valve with the tappet valve action, retaining and enhancing the advantages of both valve types. This superior valve mechanism, applied on a structure of the best design and materials, results in a drill which for hard service is the most powerful, effective and reliable machine on the market. See Pamphlet 4102.



The "Little Giant"

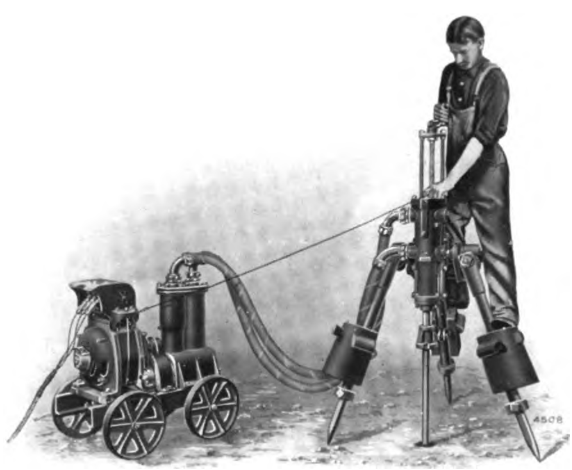
There are certain classes of work in which the tappet valve movement gives the best results. In this field the "Little Giant" reigns supreme. It was the pioneer tappet type, and has always been in advance of all competition. The latest models embody improvements making marked strides forward. As a steam drill the "Little Giant" is without a peer; and when operated by compressed air it is equally effective and economical. See Pamphlet 4003.

The "Arc Valve"

The "Arc Valve" Drill is another tappet type, differing from the "Little Giant" in that its valve, instead of being flat, is arc-shaped, and moves on an arc-shaped seat around a rocker pin. While especially adapted for wet steam, it gives even better results with dry steam or air. Many large users of the tappet type have standardized on this drill. It is a strong, simple, durable machine with a powerful blow and large capacity. See Pamphlet 4104.

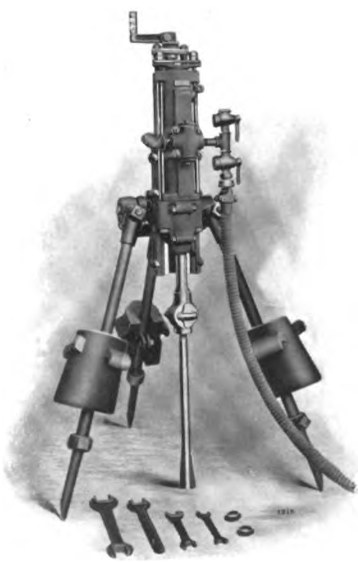
The "Electric-Air"

This machine is the first successful application of electric power to rock drilling. The secret of its success is that compressed air does the work, while electricity furnishes the power. There is nothing electrical about it but the motor; the drill has all the good features of a standard air drill. While guaranteed to be equal in capacity to a standard "Sergeant" or "Little Giant" drill of the same rating, it uses not more than one-half the power of these standard drills, while doing the same work. See Pamphlet 4109.



"The Slugger"

"The Slugger" is what its name implies — a heavy, powerful drill especially suited for heavy work. It has an air-thrown valve and can be used only with compressed air. While not a recent type, its capacity and stand-up qualities have been proved in very hard service. It is still a great favorite among many large users who know its value and is a thoroughly well-built, dependable drill of the "independent valve" class. See Pamphlet 4005 (in preparation).



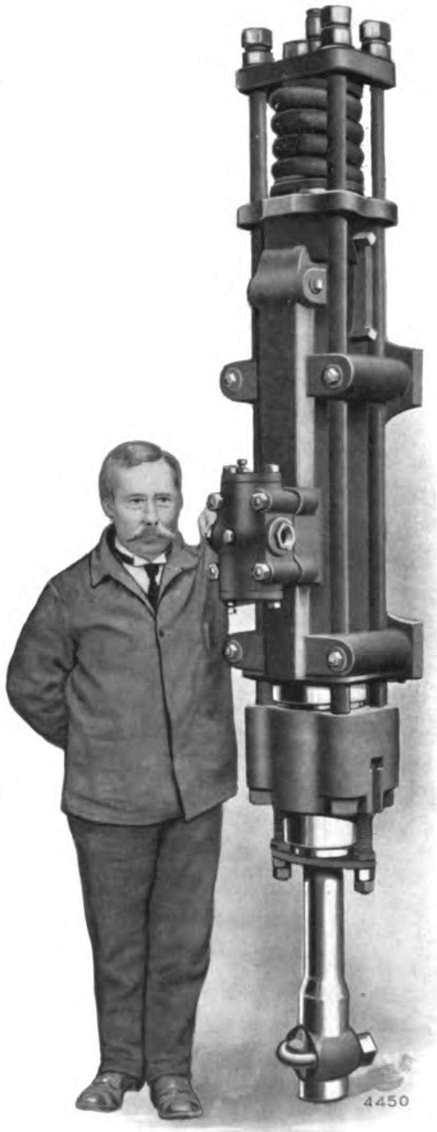
The "New Ingersoll"

This drill has an independent air-thrown valve, the movement of which is controlled by the travel of the piston. It is a model of extreme simplicity, great effectiveness and durability, but with a more limited field than some of the later types. With compressed air or reasonably dry steam the "New Ingersoll" will give excellent results in all but the hardest materials. The larger sizes in this type are particularly satisfactory machines of great power and capacity. See Pamphlet 4006.

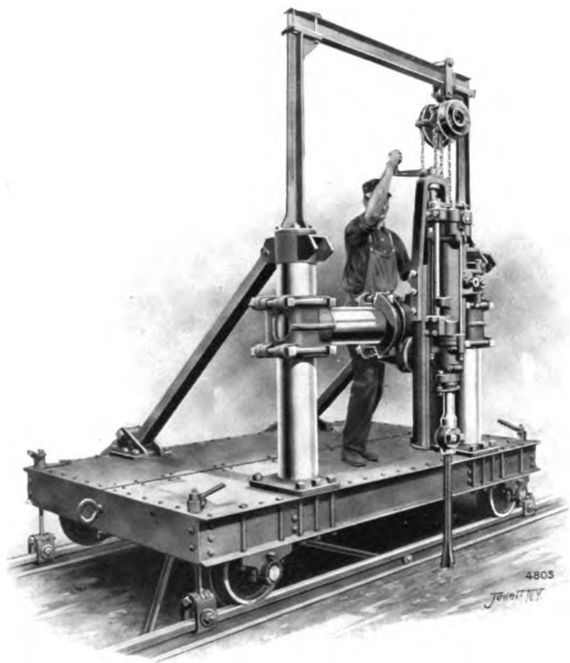
Submarine Rock Drills

The Company's submarine drills are rugged, powerful modifications of standard Ingersoll-Rand drill types, and leave nothing to be desired for this work. Probably 90 per cent of the submarine drilling throughout the world has been done with Ingersoll-Rand machines. As a result of this vast experience, crystallized in these up-to-date models, the Company's submarine types may be accepted as the standard construction for this class of work. These machines find their application in river and harbor improvements, deepening navigation channels, removing hidden reefs and ledges, canal construction, lock and dock construction, etc.

This is distinctly a specialized line of work, and the Company will be glad to advise on all problems involving submarine rock drilling. See Pamphlet 4012 (in preparation).



The "Deep Hole" Drill

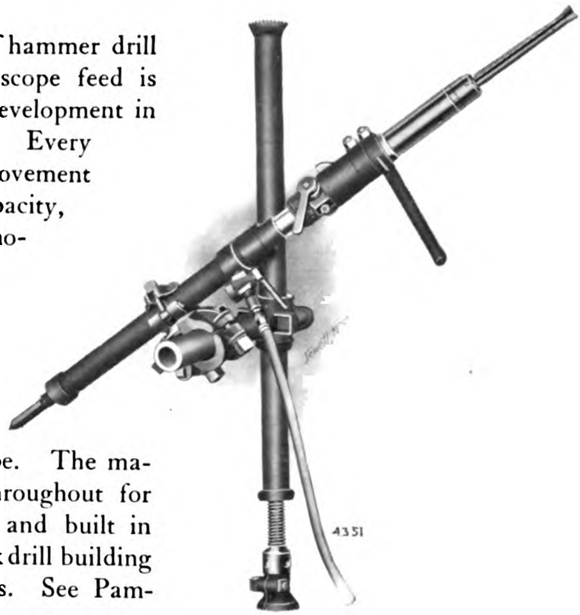


This machine has been developed as a result of the growing tendency in heavy contract work toward the drilling of large, deep holes and the breaking of large rock masses by heavy blasts. This is usually preliminary to loading by steam shovels, and the method is receiving increasing attention in canal excavation, ballast or broken stone quarries, deep railroad cuts and similar work.

The "Deep Hole" Drill consists of one of the Company's large drills mounted on a carriage or truck which is moved along to cover the row of holes. Provision is made, by chain blocks or pneumatic hoists, for raising and lowering the heavy steels used. These machines are adapted for drilling holes up to six inches in diameter to a depth of 40 feet or more. Exceptional records for speed and economy have been made with drills of this class. The above illustration shows a "Deep Hole" Drill built for the Panama Canal Other types differ in some construction details, but the general principle is as here shown. See Pamphlet 4007 (in preparation).

Telescope Feed Hammer Drills

"Crown" Drills



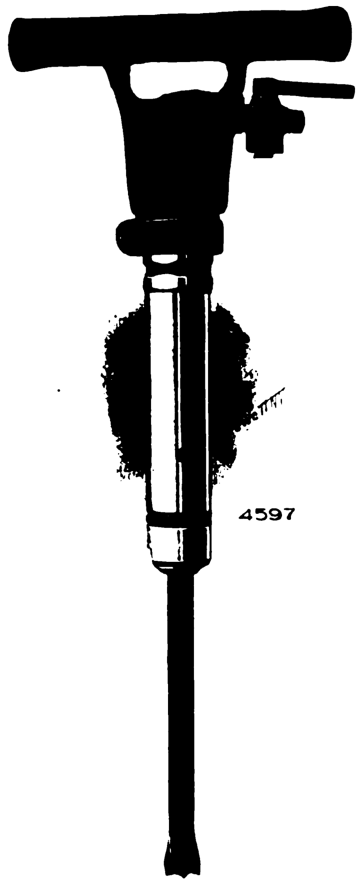
The valve type of hammer drill with automatic telescope feed is seen in its highest development in the "Crown" drill. Every up-to-date improvement which will add to capacity, endurance and economy is featured in this machine. The valve is of the well-known "Crown" air-thrown spool type. The machine is designed throughout for rock drilling service and built in shops devoted to rock drill building for thirty-nine years. See Pamphlet 4010.

"Imperial" Drills

The "Imperial" Hammer Drill has no valve; the piston performs the valve functions. There is only one moving part, resulting in a matchless simplicity. Selected materials, special steel treatment, and the hardening of all wearing parts have combined in this tool to make a machine of exceptional endurance and "stand-up" qualities. The "Imperial" Drill has made remarkable records for drilling capacity, economy of air, and low repair costs. There are single mines using hundreds of these tools which have been adopted as standard after extensive tests on all others. See Pamphlet 4010.

Hand Hammer and Plug Drills

"Crown" Drills



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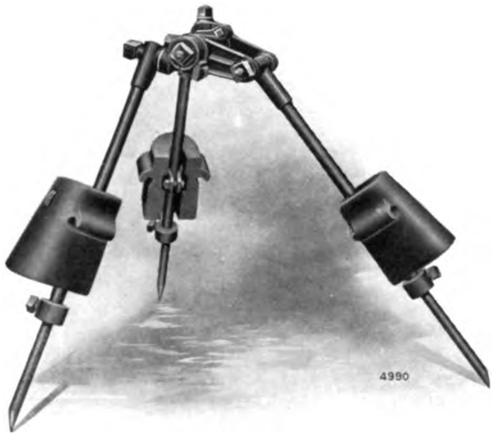
"Crown" Hand Hammer Drills, sometimes designated as plug drills in the smaller sizes, are identical in construction so far as the drill proper is concerned with "Crown" telescope feed drills. But a handle is substituted for the air-feed cylinder of the latter. The best of materials and workmanship, and correct design make these standard tools of great capacity and stand-up qualities. See Pamphlets 4013 and 4014.

"Imperial" Drills

These are valveless hand tools, offered in several sizes for different working conditions. They give splendid results in work suited to their capacity, and their extreme simplicity is one of their strongest features. It is to be remembered that all Ingersoll-Rand hammer drills are not merely modified pneumatic tools, but specially designed drilling machines, built by rock drill experts as well as it is possible to make them. See Pamphlet 4015.

Drill Mountings

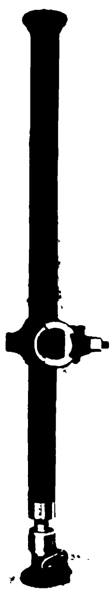
"Sergeant" and "Rand" Tripods

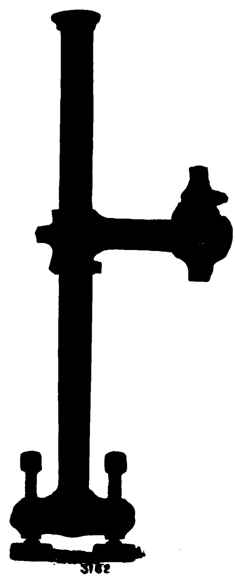


These tripods are the standard mountings for the Company's rock drills of all types, especially adapted to quarry or open-cut contract work, but used to a limited extent also in mining work. They combine a wide adjustability with great strength and rigidity. See Pamphlet 9003.

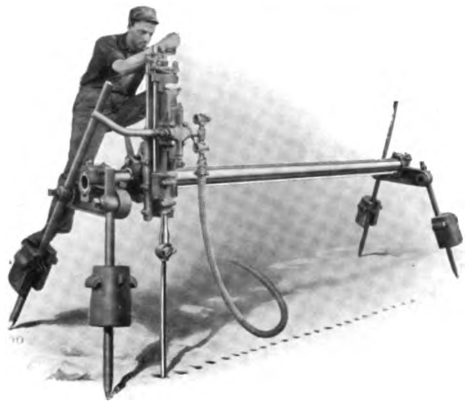
"Sergeant" and "Rand" Columns

These columns, in single and double screw type, are used chiefly in mining work. The single screw column usually has the drill mounted upon it direct. With the double screw column a column arm is generally used. Drill clamps, or saddles, and safety collars are part of the equipment furnished where a complete column is ordered. The Ingersoll-Rand construction of these mountings gives the maximum strength with the minimum of weight, and great convenience of adjustment. Columns of all standard diameters and lengths can be furnished. See Pamphlet 9003.





The Quarry Bar



This is used in quarries or contract work where a row of parallel, closely-spaced holes is wanted, in any plane from vertical to horizontal. Its great application is in plug-and-feather work, broaching, lofting and cutting out key blocks. The wall between the holes may be cut out with a broaching bit in the drill. See Pamphlet 9003.

The Gadder

The Gadder is a portable mounting peculiar to quarry work, using standard drills for putting in a row of holes in a side wall at any angle from horizontal to vertical. These holes may be broached or the break may be made by the plug-and-feather method. See Pamphlet 9003.

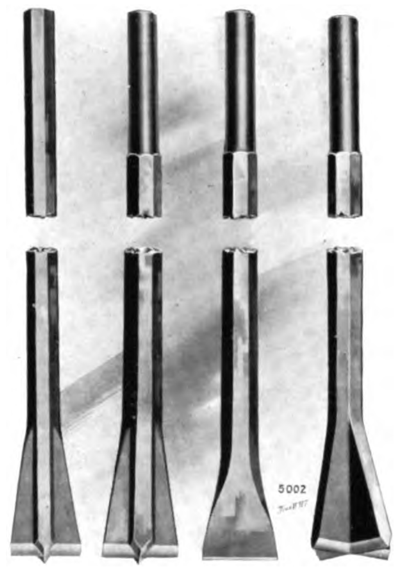
The "Auto-Screw" Frame

This device, developed for submarine drill work, is in essentials a very long feed shell for a heavy drill, with a long feed screw operated by an air motor or other means at the top. It is mounted on the framework of the drill barge or scow. See Pamphlet 4012 (in preparation).

Rock Drill Accessories

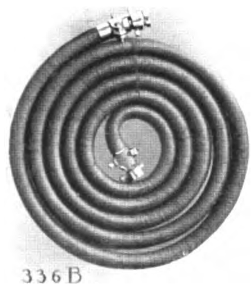
Drill Steels

The Company carries a full line of steels for all its drills, whether of piston or hammer type, and can make quick deliveries on demand. These steels may be had with or without bits and shanks, and the bits may be of any style desired. Steel of the very best quality is used. As the drilling capacity of a machine depends very largely upon its steels, it is important that the latter should be the very best, and carefully sharpened and tempered. The very best results may be expected from Ingersoll-Rand steels. See Pamphlet 9003.

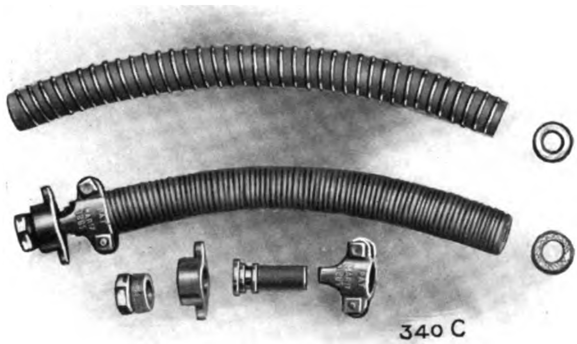


Steam and Air Hose

Steam and air hose in any ply and size desired is furnished by the Company for use with either piston or hammer drills. The style may be plain, canvas wrapped, linen wrapped, marline wound or wire wound. In the latter case, round, half round or flat wire winding can be supplied. The quality in any style is guaranteed to be the very best obtainable, affording the best value for the price. See Pamphlet 9003.

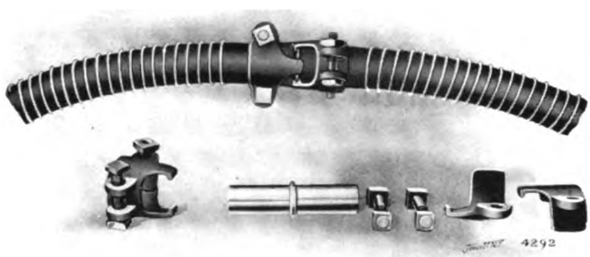


"Sergeant" Hose Couplings



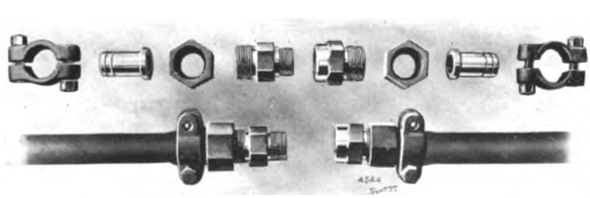
Long experience has proved that the "Sergeant" Coupling is the best, strongest and most durable coupling for the rough duty of rock drill work. It is simple, rugged, easily and quickly applied, and maintains a tight joint. See Pamphlet 9003.

"Sergeant" Hose Menders



These are practically identical in construction with the "Sergeant" Coupling, differing only in the detail that the joint is intended to be more permanent and not frequently made or broken See Pamphlet 9003.

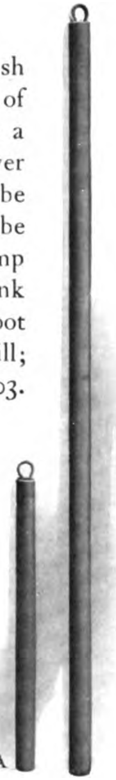
"Crown" Hose Couplings



These are light couplings devised for use on the smaller sizes of hose used with hammer and plug drills. They embody every desirable feature, and are simple, strong and reliable.

Sand Pumps

"Down" holes in rock forming a mud which will not splash out must be cleaned at intervals—usually at every change of steels. For this purpose the sand pump is used. It is a section of wrought iron boiler tube having a valve at its lower end which opens to admit the slush, but closes when the tube is lifted. At the upper end of the tube a chain should be attached, made up of several links of rod by which the pump is forced to the bottom of the hole. A ring at the last link prevents the chain from dropping in the hole. The two-foot length is used for cleaning holes without moving the drill; others are intended for deep holes. See Pamphlet 9003.

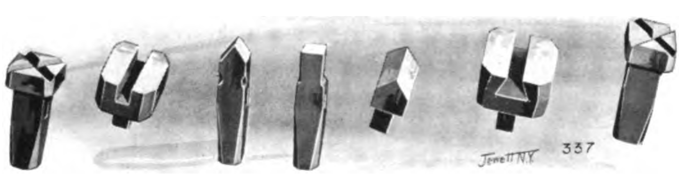


336A

Blacksmith Tools

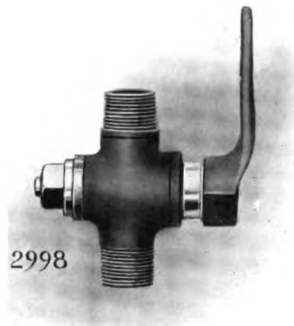
The proper sharpening of rock drill steels is a very important factor in rock drilling economy. The footage made by a drill depends very largely upon the proper forging and sharpening of the drill bits. Bits not true to gauge result in rifled holes and stuck steels. Bits not properly tempered cut down the drilling rate of the machine. For this important work the Company furnishes the special blacksmith tools here illustrated. They are not a part of a regular drill equipment, but will be furnished on order. While designed for this special class of work, they are in essentials very similar to the ordinary smith tools; and an intelligent blacksmith will quickly master their use and turn out good bits.

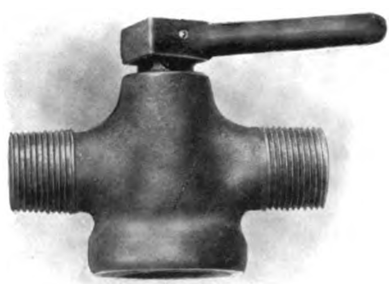
Two distinct styles are offered. One is for the ex (×) shape of bit and the other is for the cross (+) bit. As sent out, these tools are hardened, and ready for use. A standard set consists of sharpening tools only. Swedges for forming shanks on drill steels will be furnished on order. See Pamphlet 9003.



The "Old Style" Throttle

This is a strong, heavy, straight-way taper plug throttle valve designed for rough rock drill service. It is a reliable and satisfactory valve at moderate cost. It is made of composition metal and wear is taken up by tightening the nut on the end of the taper plug opposite the handle. See Pamphlet 9003.





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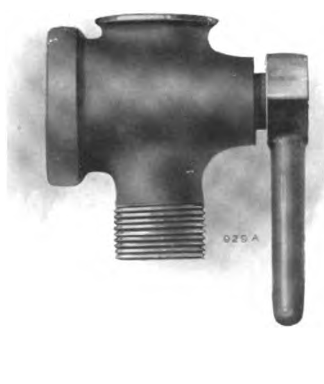
The "New Ingersoll" Throttle

The "New Ingersoll" Throttle is an improved device easily kept tight, working freely, and automatically self-adjusting under wear. It is a higher priced throttle than the "Old Style," but well worth the difference. See Pamphlet 9003.

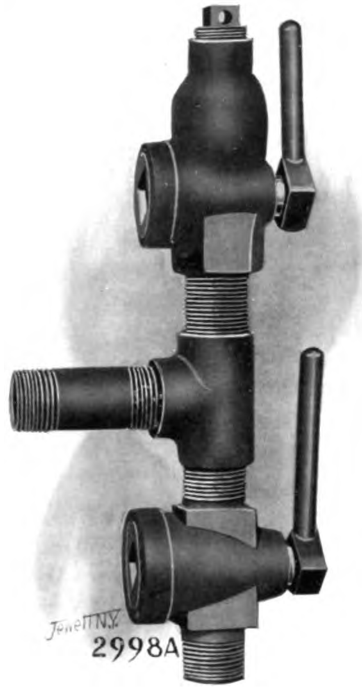
The "New Ingersoll" Oiler

This device closely resembles the "New Ingersoll" Throttle. Its taper plug has a cup on one side, which is filled with oil, after which the handle is turned down, emptying this oil into the supply pipe. Throttle and oiler are usually coupled up on a "T" connection. See Pamphlet 9003



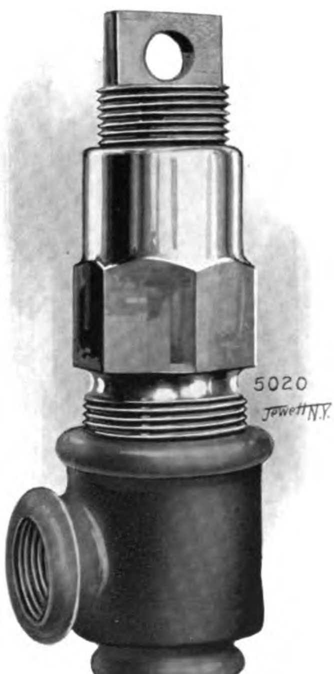
The "Reservoir" Oiler

This arrangement operates on the same principle as the "New Ingersoll," but has at the top a reservoir filled through a plugged opening and holding enough oil for half a shift. The oil is always there, is always clean, and the ease with which it is fed to the drill by a turn of a lever leaves no excuse for the inadequate lubrication of the machine. This is a very economical and satisfactory device. See Pamphlet 9003.



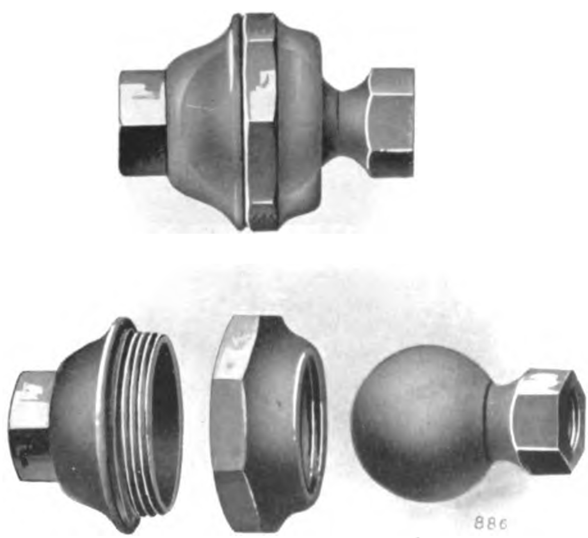
The "Heart-Beat" Oiler

Something distinctly new in the oiler line is here offered. An absorbent cartridge, saturated with oil, is placed inside the oiler casing and the oil is gently fed to the drill under the pulsations of the air or steam. Three or four cartridges suffice for the average shift. The saturated cartridges are delivered to the driller at the beginning of the shift and returned by him dry at the end. This arrangement puts the proper oiling of the drills in the hands of the manager or superintendent, who can always see that dry cartridges are returned and saturated cartridges given out at each shift. Operation is entirely automatic and unfailing.



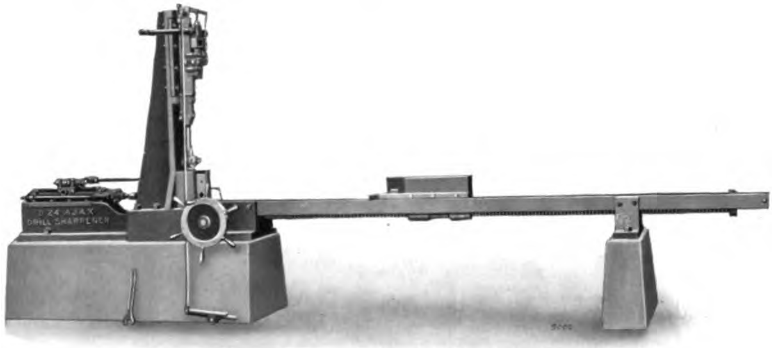
The Manifold or Header

This arrangement is used where a number of machines working in a limited area are supplied from one pipe line. It can be furnished in a number of sizes, with 4, 6, 7 or 10 branch openings. See Pamphlet 9003.



The Flexible Pipe Joint

This is a ball-and-socket joint for use in temporary pipe lines in quarry or open cut excavation. It gives great flexibility to the line over an irregular surface and permits moving the pipe out of the way of the blast. It will stand all ordinary pressure and is furnished tapped for standard pipe. See Pamphlet 9003

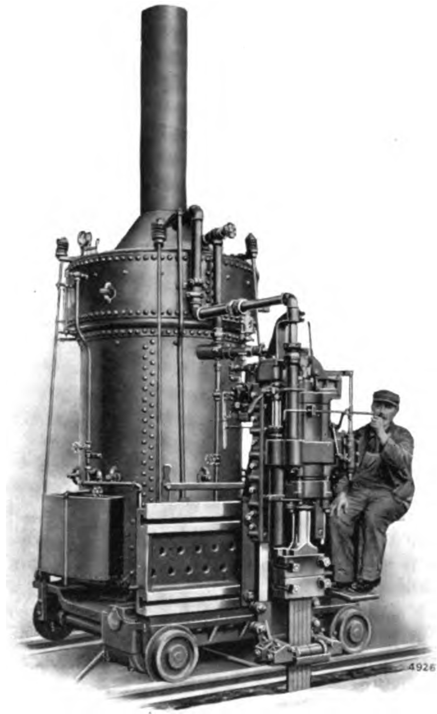


The "Ajax" Drill Sharpener

The "Ajax" Drill Sharpener is designed for forging and sharpening drill bits by means of compressed air hammers. These hammers are modified Ingersoll-Rand rock drills. The unmatched records for endurance made by the Company's drills is a guarantee of the "stand-up" qualities of these important parts of the "Ajax" sharpener. Another advantage is that duplicate repair parts for the hammers can be quickly supplied from any Ingersoll-Rand branch or agent. Exceptional records have been made with this machine, and a man familiar with its operation can turn out two finished bits per minute. In its several sizes the machine will handle steels of all lengths and bits of all diameters. It will not only sharpen dull bits, but it will forge new bits from round, octagon or cruciform steel. The bits thus made are true to gauge and of exceptional wearing qualities. Experience has shown that machine-sharpened bits will cut 30 to 50 per cent more rock than hand-sharpened steels, and their uniform gauge practically does away with all "rifling" of the hole.

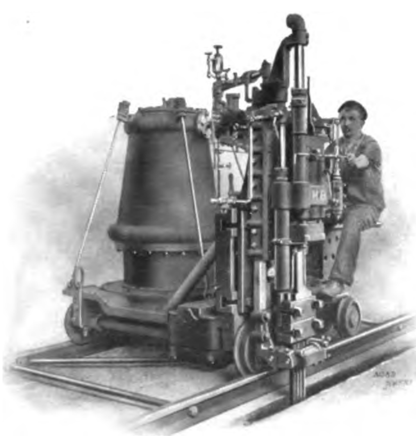
Three sizes of the "Ajax" meet all conditions of drill sharpening. The original "Ajax" machine is practically universal in its application, forging and sharpening steels of all bit diameters and of all styles of bit. It is made in two lengths, for 9½- and 13½-foot steels. The "D-24 Ajax," illustrated above, is for bits 1½ to 4 inches in diameter, and for steels from 10 to 35 feet long. It will handle both chisel and cross bits. The "A-86 Ajax" handles steels up to ten feet in length, with bits from 1 to 2¼-inch diameter. It produces chisel, cross or rosette bits. See Pamphlet 513.

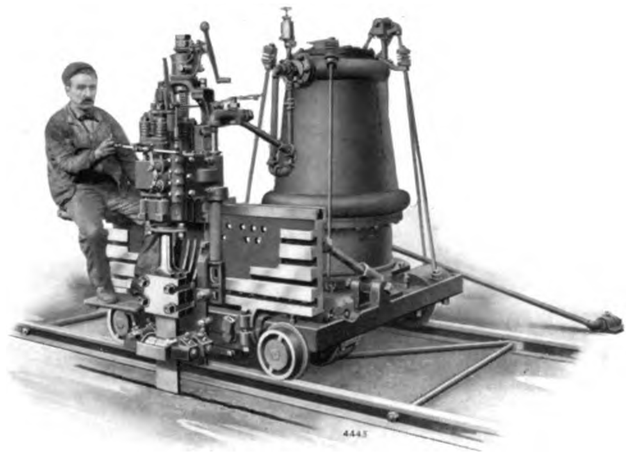
Stone Channelers



The "Monitor" Heavy Duty Track Channeler

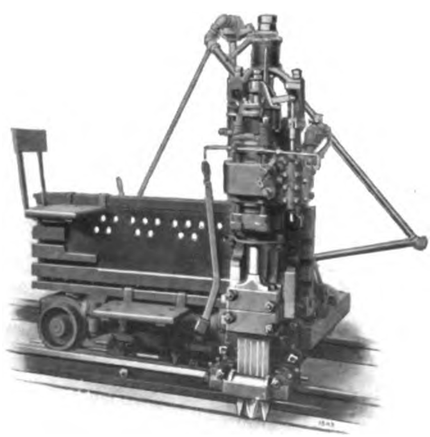
The "Monitor" Track Channeler is a direct-acting, single-gang, steam or air driven machine marked by a massive strength and by important features of design which guarantee a splendid economy, high power, great reliability, and a tremendous cutting capacity. It is a machine designed for the heaviest work and the deepest cuts in quarries of sandstone, limestone, slate or other rocks, as well as in certain classes of contract construction. The steam driven "Monitor" is furnished with an upright boiler; the air driven type can be furnished with or without an air reheater. Many - exclusive improvements have carried these machines beyond all previous records and they have been adopted as standard by many of the largest quarry interests. Superior design, high-class construction, and the best of materials combine to make the "Monitor" the standard heavy-duty channeler. See Pamphlet 6003 (in preparation).

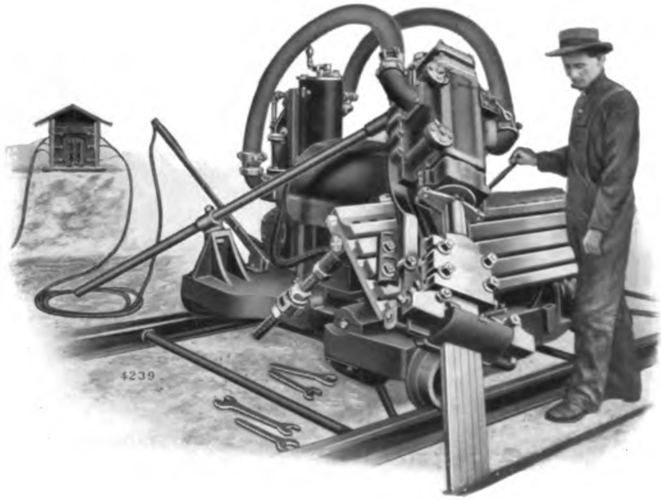




The "Ram" Marble Channeler

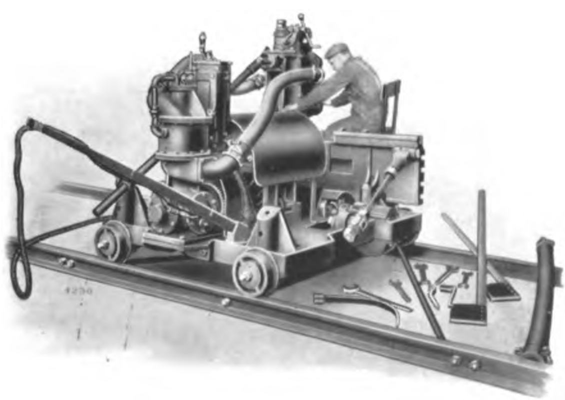
The "Ram" Channeler is a modification of the "Monitor" type, with special features adapted to marble quarrying. In this class of work, while large power and capacity are required, it is important that the blow may be under perfect control so that the marble may not be stunned, shattered or otherwise injured in cutting. For this reason a special controlling device is a feature of this machine. Swing back and swivel head adapt it for working in deposits at any angle. The machine is light and easily moved, yet equal to the hardest service. The "Sergeant" roller guide is a patented feature of this, as of all other Ingersoll-Rand channeler types, and adds to their speed and capacity. The "Ram" Channeler may be furnished with a boiler, and with or without an air re-heater. In whatever type, it is a money-maker in the quarry which cannot be ignored by progressive managers. See Pamphlet 6004 (in preparation).

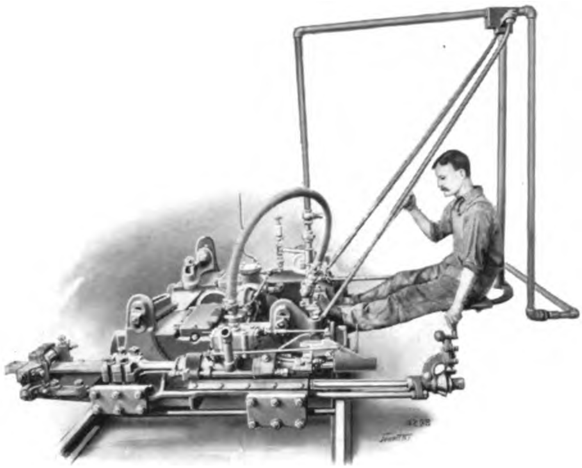




The "Electric-Air" Channeler

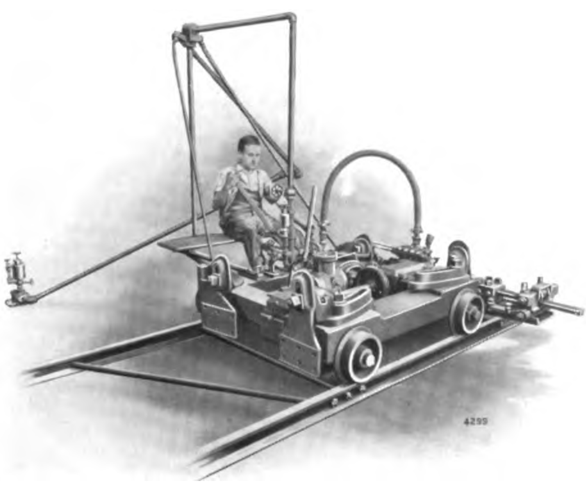
This is the latest development in quarry machines and embodies the "electric-air" principle which has met with such remarkable success in the "Electric-Air" Drill. The cutting engine operates by pulsations of compressed air produced by a motor-driven air pulsator. The machine is self-contained, all of the mechanism being on the channeler truck. All the capacity and endurance of the "Monitor" type are retained, while the power consumption is reduced not less than 50 per cent by the "electric-air" principle. All piping, steam, smoke, coal, ashes, etc., are eliminated from the quarry. The "Electric-Air" Channeler has demonstrated its practical success in some of the largest quarries of the country; and "repeat" orders are proof of its satisfactory performance. See Pamphlet 6102.

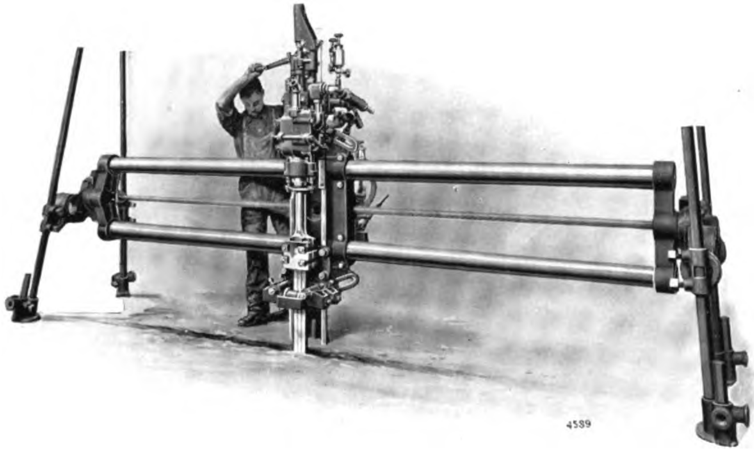




The "HF" Undercutter

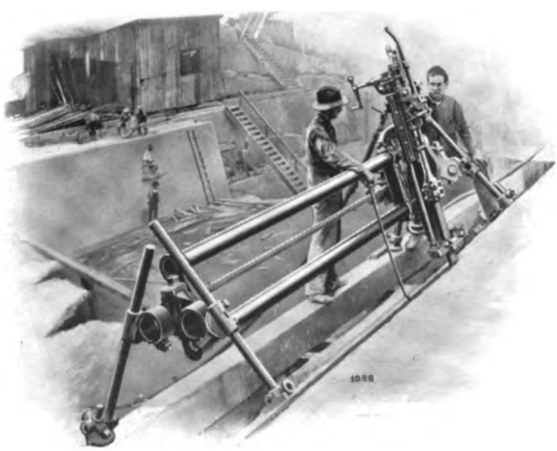
The "HF" Channeler is a standard machine for undercutting in materials with no free cleavage lines or where for other reasons the bench cannot be raised by ordinary means. It is also useful for tunneling and cutting under ledges. All important improvements are incorporated in this machine; notably, the roller guide, independent engines for cutting and travel, and adjustment of the cutting engine in vertical and horizontal planes. This is not merely a rock drill mounted on a truck, but a complete, high-class, powerful channeling machine. The best features of the "Monitor" type are retained. The cutting engine can be mounted on either end of the frame. See Pamphlet 6006 (in preparation).

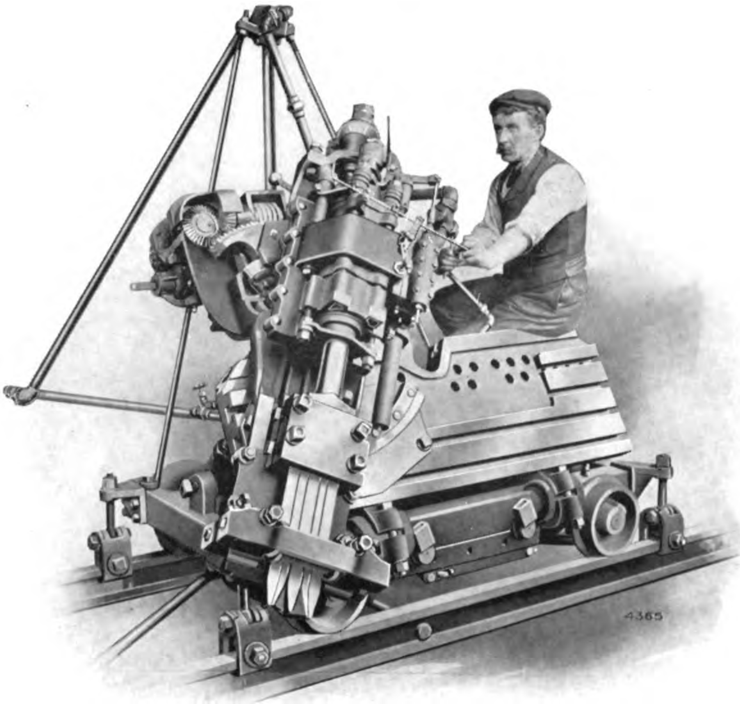




The "Broncho" Channeler

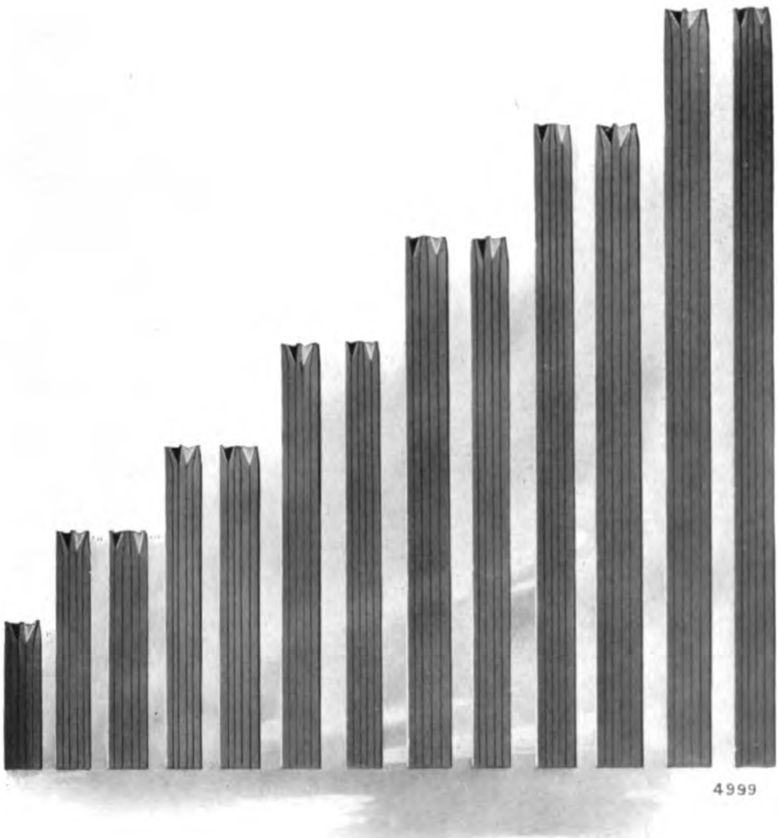
The "Broncho" is an advanced type of the bar channeler especially useful in the development and opening up of new quarries. It has also found extensive application in some classes of contract work for making smooth wall cuts. It is used in operating quarries for broaching, plug-and-feather work, lofting, etc. In it all improvements have been retained which would properly have a place in a channeler of this type. Ready portability, complete control, wide adjustability, high power, good economy and large cutting capacity distinguish this machine and make it the best bar channeler on the market. It is a perfected high speed, rock cutting machine, not merely a rock drill on a frame. Pamphlet 6005 (in preparation).





The "Corner Cutter"

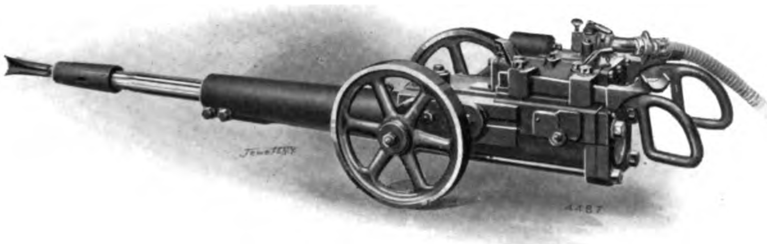
The "Corner Cutter" or Radial Track Channeler is a distinctly new machine developed for a specialized line of quarry work. It is intended for cutting out corners and making transfer cuts. It has the swing back of the ordinary channeler, but the swivel head is replaced by a radial mounting by means of which the cutter can be swung at any angle up to 45 degrees either side of vertical. This radial swing is produced by means of an air engine operating through worm gears. There is an independent engine for the track travel. The cutting engine proper is very similar to that of the "Monitor" or "Ram" Channelers, having the improved valve movement, the cushioning valves, and other features giving complete control and large cutting capacity. See Pamphlet 6007 (in preparation).



Channeler Steels

The Company is prepared to furnish channeler steels for all its standard channeler types, in all sizes and lengths, and singly, in gangs or in complete sets. These steels may be had in blank or with bits forged in place. The best of material is used and the maximum service may be expected. Special care in tempering, sharpening and aligning channeler steels is well repaid in the improved cutting capacity of the machine. Quick deliveries can usually be made in all ordinary lengths.

Coal Cutters



The "New Ingersoll" Puncher

The "New Ingersoll" Puncher is a machine for making the undercut in a coal face preliminary to shooting down the coal by a blast. Maximum capacity with minimum cost for power and repairs explain its leadership among the most successful mines of the country. There are customers using hundreds of these machines and hundreds of mines using from five to fifty. The "New Ingersoll" is an "all-around" puncher, adaptable to hard or soft coal, thick or thin seams, high or low air pressure. Its blow is under complete control. It strikes harder than any other puncher, costs less for repairs, and has every good feature found in any machine of its class, with many advantages distinctly its own: Pamphlet 5002.

The "Air Radialaxe"

The "Radialaxe" is a special machine adapted to four problems which confront mine operators: first, entry and heading driving; second, shearing; third, cutting out dirt or clay bands; fourth, undercutting and shearing in a pitching seam.

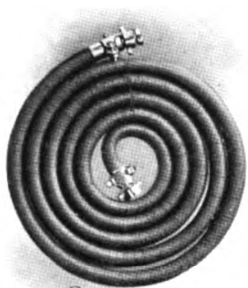
The "Radialaxe" does all four of these operations better and more cheaply than any other method. It is a modified rock drill on a column mounting, with means for swinging it in a plane at any angle. Beside the four lines of work here defined as belonging peculiarly to the "Radialaxe," the machine may also be used for regular rock drill work, such as "brushing" entries and taking down rock roofs.

The "Radialaxe" is built in the same shops, by the same men and methods, as Ingersoll-Rand rock drills. It has passed the experimental stage and is now a standard product, thoroughly demonstrated in practical service. It is not a machine of universal application, but in its own place is one of the most valuable machine accessories offered to the coal trade in recent years. See Pamphlet 5003.

The "Electric-Air Radialaxe"

This machine is intended for the same work as the "Air Radialaxe," and in fact uses the same mounting. But it operates on the "electric-air" principle, and a motor driven pulsator is a part of the equipment. The motor used can be of an enclosed, dust-and-gas-proof type. It is geared to a duplex single-acting air pulsator which delivers its pulsations through two lengths of hose to the alternate sides of the "Radialaxe" piston. This machine is fully equal in capacity to the standard "Air Radialaxe," but operates with a power consumption of not more than one-half that of the latter.

It solves the problem of shearing, cutting out bands and undercutting in a pitching seam, in the electrically equipped coal mine. No air piping is needed for its operation, but only a line of wire from the nearest source of electric power. The pulsator has large truck wheels, either plain, or flanged for running on a track, as ordered. The entire arrangement is conveniently set up, easily moved from place to place, and one machine will cover a good deal of ground in its special work. See Pamphlet 5004 (in preparation).



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Air Hose

The air hose furnished by the Company for punchers and "Radialaxe" machines is of the best quality and has the standard "Sergeant" couplings. It can be supplied in any of the standard plies or styles of covering or wrapping. The best hose is the least expensive in coal mine work, which is exceptionally hard, even on the best; and wearing qualities will be in proportion to the price.

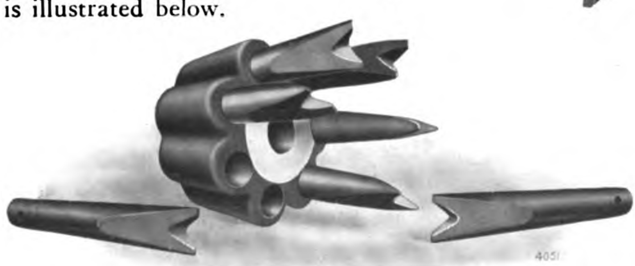
4050

Coal Picks and Bits

The Company is prepared to furnish picks or bits for the "New Ingersoll" Puncher or "Radialaxe" machine, of the best quality of steel, made of the proper shape and in every way adapted for the best operating results.

Puncher picks are of the solid two-prong style and are shipped without tempering. The temper should be adjusted to the hardness of the coal being worked. Sharp picks increase the capacity of the puncher and well repay the care in maintaining them.

"Radialaxe" bits are furnished in two styles: the three- or five-prong solid bit, forged in one piece; and the combination bit consisting of a bit holder and a number of small two-prong or "fishtail" bits fitting in the holder on a taper. The latter is illustrated below.



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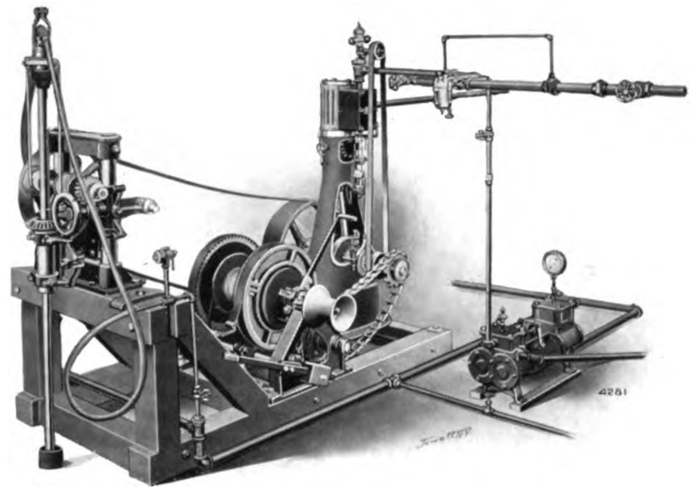


The "Calyx" Core Drill

The "Calyx Diamondless" Core Drill differs from the ordinary diamond core drill in that it uses chilled shot or a steel cutter in place of the costly diamonds. This eliminates at once one of the principal items of cost in core drilling. In fact, a complete "Calyx" outfit may often be purchased at a price which would hardly cover the diamond bit alone for an ordinary diamond drill.

The standard line of "Calyx" Drills includes machines driven by steam, gasoline engine, hand, horse or independent prime mover. There is almost no limit to the depth capacity and standard sizes will handle cores from $1\frac{5}{8}$ to 20 inches in diameter. The "Calyx" Drill will remove cores in any material from 30 to 50 per cent cheaper than any other method of core drilling.

The following are some of the applications of the "Calyx" Drill: prospecting for minerals, ore, coal, clay, stone, etc.; foundation soundings for buildings, bridge piers, locks, dams and docks; testing foundations and walls of brick, stone, concrete, etc.; drilling wells for water, oil or gas; testing or prospecting deposits of stone, slate, marble, etc.; drilling large holes in earth or rock for contract work; drilling large holes for plunger elevators, ash hoists, mine ventilators, ore chutes, winzes, ammunition transmission, anchor bolts, etc. See Pamphlets 9001, 9004, 9005 and 9006.

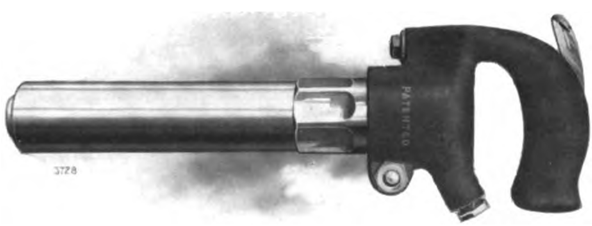
Pneumatic Hammers

The Company offers two lines of pneumatic hammers for chipping, riveting, calking, and all the other purposes for which these tools have found application.

All these machines are built as well as it is possible to make them, and are marked by distinctive superiorities in design and construction. Wearing parts are of hardened and ground steel. Special oil treatment of steels results in a product of exceptional wearing qualities.

"Crown" Hammers

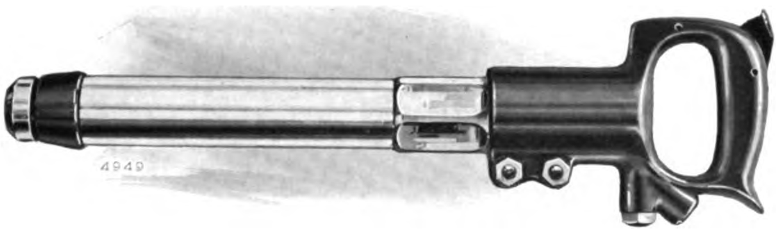
"Crown" Hammers have an air-thrown valve moved by unbalanced pressures, giving a quick, positive movement to the piston and a very hard blow. The valve is of the simplest spool type, traveling in a hardened steel valve box in the same direction as

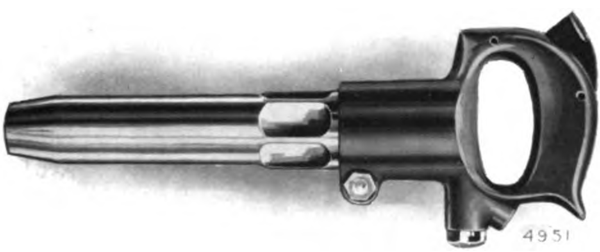


the piston or hammer. "Crown" Chipping Hammers are made in five sizes, covering the usual range of chipping work. The two largest sizes of chipping hammer can also be used for driving small rivets. The riveting hammer is made in three sizes, for the usual duties. See Pamphlet 8002 (in preparation).

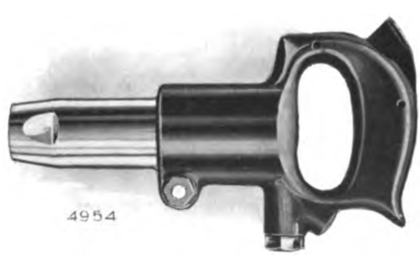
"Imperial" Hammers

"Imperial" Hammers have a cup-shaped valve concentric with the piston; in fact, the piston travels within the valve at the end of its stroke, thus making a shorter hammer than in other constructions. The blow of the "Imperial" is of maximum effectiveness.



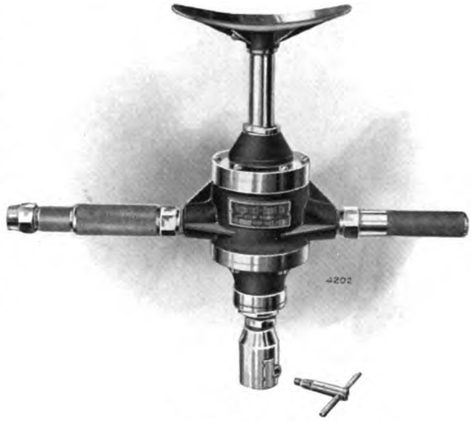


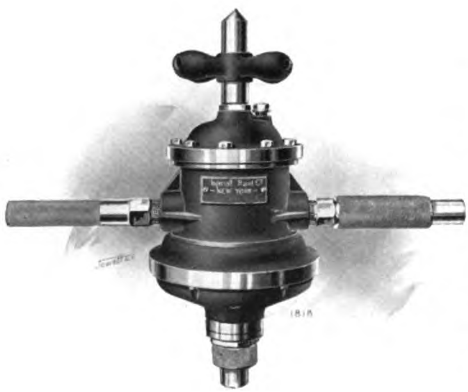
As the hammer cushions on live air, there is practically no vibration or jar on the operator. The "Imperial" hammer is made in two sizes for scaling, five sizes for chipping, and four sizes for riveting. The usual range of pneumatic hammer work is covered in these eleven sizes. See Pamphlet 8003.



Pneumatic Drills

Pneumatic drills of the most approved type are furnished by the Company, adapted for wood and metal boring, drilling, reaming, tapping and the other ordinary applications of machines of this class.

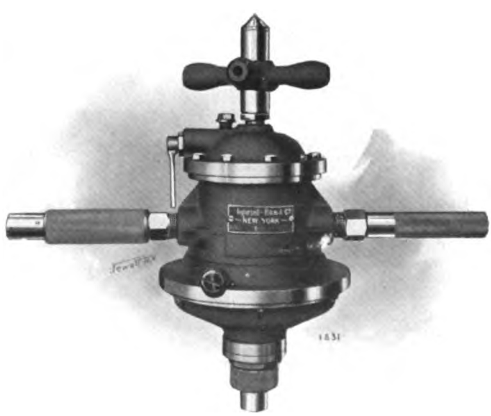




"Crown" Drills

"Crown" Drills use a rotary pneumatic motor, and are distinguished by a remarkable simplicity and a tremendous power. All ordinary demands can be met in standard sizes of these drills.

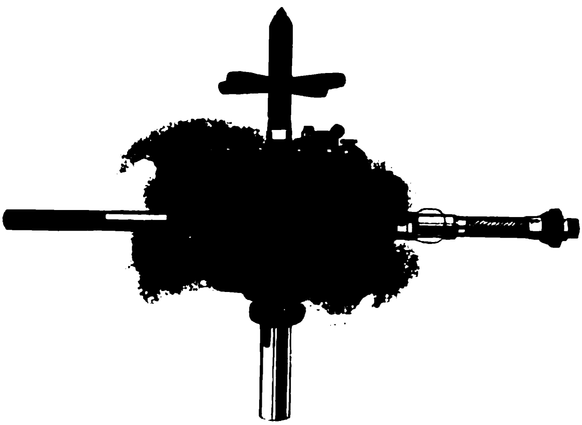
Both plain and reversing types can be supplied. Selected and specially treated materials, bushed bearings, and ample lubrication make these machines of great wearing qualities and economy of power and repairs. See Pamphlet 8104.

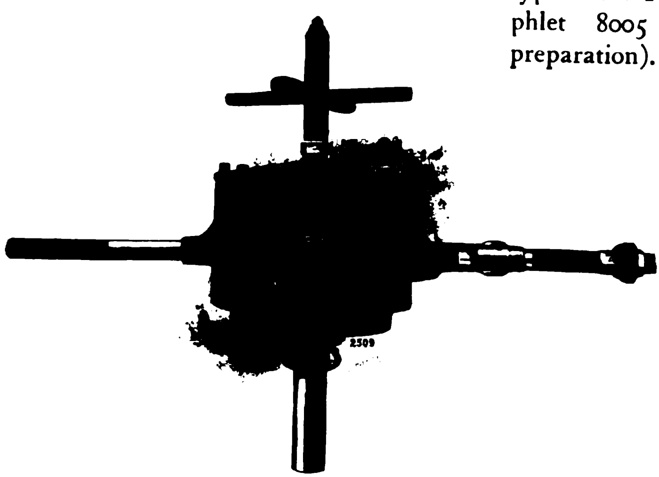


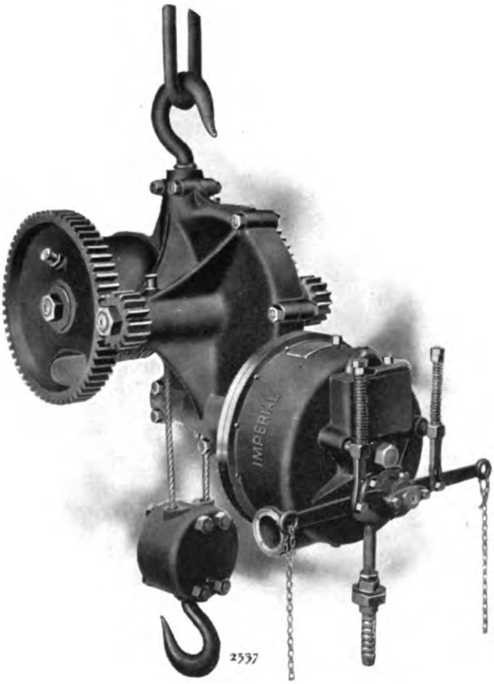
"Imperial" Drills

The "Imperial" Drill uses a three-cylinder motor with a central valve. It is an exceptionally well-built machine. All bearings are large and parts are of selected steel com-

bining great strength with lightness. The motor is balanced and free from vibration at any speed. Eight sizes in the "Imperial" line—six reversible and two non-reversible—cover all demands in machines of this type. See Pamphlet 8005 (in preparation).

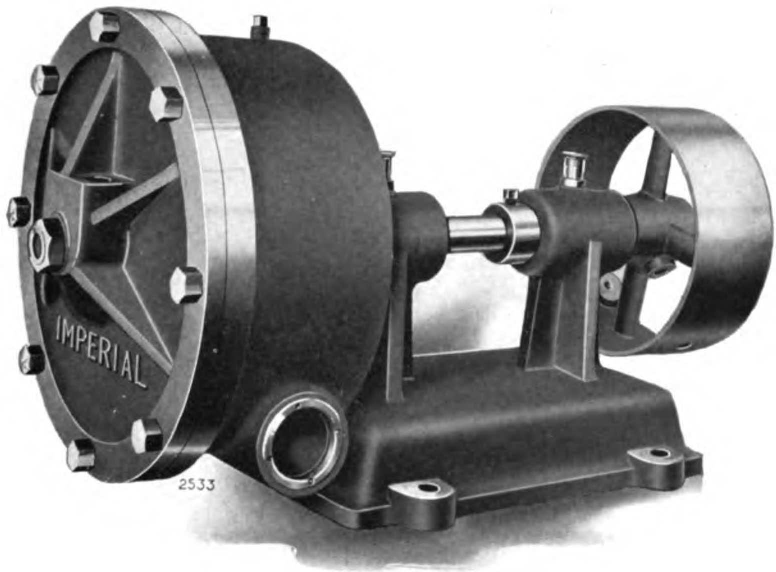






The "Imperial" Motor Hoist

The "Imperial" Hoist is offered in five sizes, from one-half to five tons' capacity, with a standard lift of twenty feet. It is an enclosed, dust-proof, splash-oiling device with every bearing fitted with renewable bushings and operating in an oil bath. The worm gearing affords an automatic lock in any position without the use of a brake. The "Imperial" has no vibration at any speed, adapting it peculiarly to problems of delicate hoisting where a jar, jerk or vibration would result disastrously. It is the ideal hoist for foundry purposes, as copes or molds can be handled without jarring the sand. This is one of the Company's most satisfactory products, and once introduced it has found unexpected applications resulting in "repeat" orders. Its labor-saving qualities have won a general recognition in shops, foundries, warehouses, stone yards, monumental works, ice plants, etc., where rapid and economical handling of work and materials is essential. See Pamphlet 8006.



The "Imperial" Air Motor

The "Imperial" Air Motor is really the motor from the "Imperial" hoist, mounted on a sub-base or bed. It is made in two sizes, rated at 2 and 3¼ horse-power. It has found useful application for isolated and intermittent service in such work as the operating of small tools or cranes in shop, foundry, freight yard, warehouses, stone yards and quarries; the driving of small chain or rope drums and winches; emery, buffing and polishing wheels; fans, short lines of shafting; operating turn-tables, boring bars, and locomotive valve setting machines. Its advantages recommend it above all others for plants where compressed air is available for other purposes. It is powerful, compact, simple, economical, and requires the minimum of attention.

It is to be clearly understood that the "Imperial" motor cannot be used with steam, nor is it intended for steady and continuous service. While the design is entirely adequate for high-duty intermittent operation, the small dimensions do not permit of the mechanical details demanded for continuous operation. See Pamphlet 8006.

4564

"Crown" Sand Rammers

The "Crown" Pneumatic Sand Rammer has made a permanent place for itself on grounds of economy, lower production cost, larger output and improved quality of product. Used in the foundry for ramming and peining molds, observations under a great variety of conditions and on work of all classes have shown that the "Crown" Rammer brings about a saving in time of 75 to 85 per cent over hand ramming. In addition to this it produces castings of a better quality, uniform in character and true to pattern. This machine has also found extensive application for ramming concrete in the production of building blocks, architectural forms, sewer pipe, etc.

"Crown" Rammers are built as well as long experience can make them, from the best materials, and they are characterized by a remarkable "stand-up" quality. See Pamphlet 8108.

Stone Tools

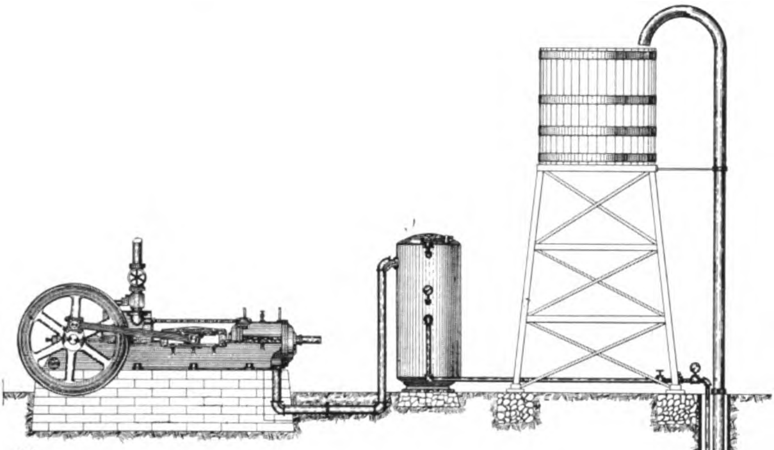
The Ingersoll-Rand Company produces a line of valveless stone tools adapted for the usual requirements of stone service and in several sizes covering a range of work from the heaviest cutting to the most delicate tracing: Pamphlet 2004.

Pneumatic Tool Hose

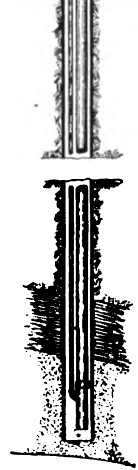
The Company furnishes a special brand of superior hose manufactured expressly for pneumatic tool service and containing a seamless inner tube or lining that will not peel off. This lining is covered with layers or plies of linen. This hose can be supplied either in plain style or with wire winding. It is not a cheap hose, but the best for pneumatic tool service.

The "G-A-T" Hose Coupling

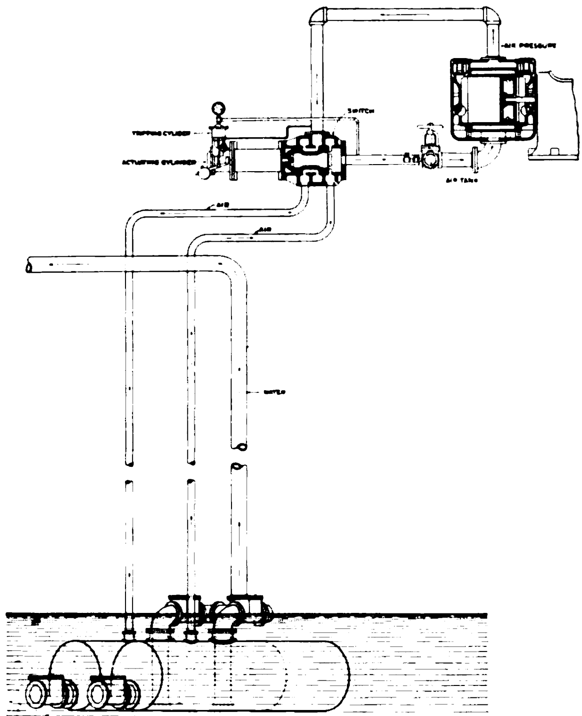
This coupling has been designed to furnish a simple, strong and quick-acting device for use with pneumatic tools. To complete a coupling it is only necessary to push the halves together by hand and slightly twist the locking rings; to uncouple, this operation is reversed. As both halves of the coupling are identical it is not necessary to mate ends.



The "Air Lift" Pumping System



The "Air Lift" Pumping System is a method of lifting water or other fluid by means of compressed air without the intervention of any valves, cylinders, plungers, or other mechanism. Its greatest field of application is in the pumping of driven wells, in which service it returns an economy probably higher than any other pumping system. It has also been used for unwatering mines, pumping water for irrigation, and in fact for all industrial purposes where a supply of water is required. The "Air Lift" has also been applied to the pumping of oils and salt solutions. In chemical and manufacturing processes it has been found of peculiar value for transferring oils, acids, alkali solutions and other materials for which the ordinary metallic pump would not be adapted. It is also used for handling slimes in the cyanide process of ore treatment. To a limited extent it has been applied in filtration processes, and in the pumping of sand and sewage. A strong feature of the "Air Lift" is that there is nothing but piping in the wells or other source of fluid pumped. All machinery is in the compressor room and operates under the best conditions. Any number of wells can be pumped from one compressor plant and each controlled from the plant by means of a valve in the air line. See Catalog 74.

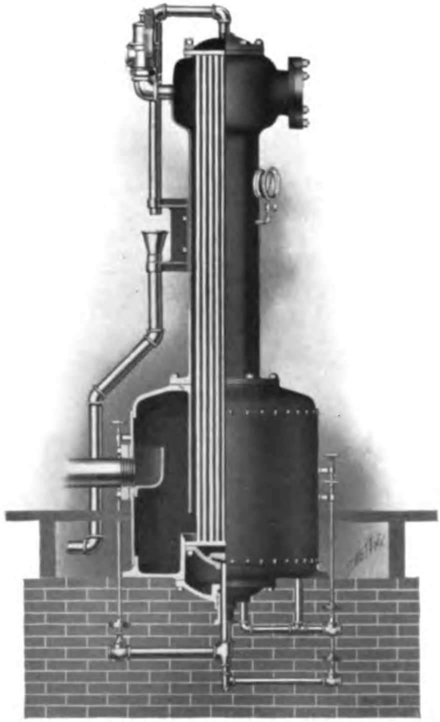


4137

The "Return-Air" Pumping System

The "Return-Air" Pumping System is a device for moving or lifting volumes of water or other fluids or semi-fluids by means of direct displacement with a volume of compressed air. It differs from the ordinary displacement pump in that the air is not exhausted after displacement, but is returned to the compressor intake. As a result of this operation in a closed circuit, the "Return-Air" System has a higher economy than any other displacement system. There is no mechanism in contact with the material pumped and the system will handle any substance sufficiently fluid to pass its valves. Applications of the "Return-Air" System are found in pumping water, sewage, glass sand, pulp, marl, cement slurry, concentrator slimes, etc. It is especially adapted for use as a station pump in mines. See Catalog 74.

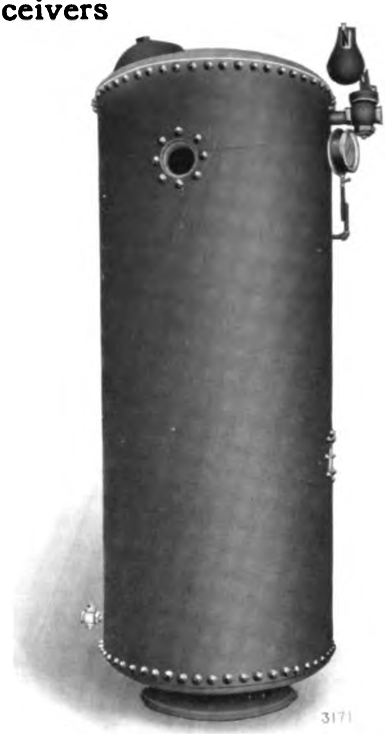
Aftercoolers



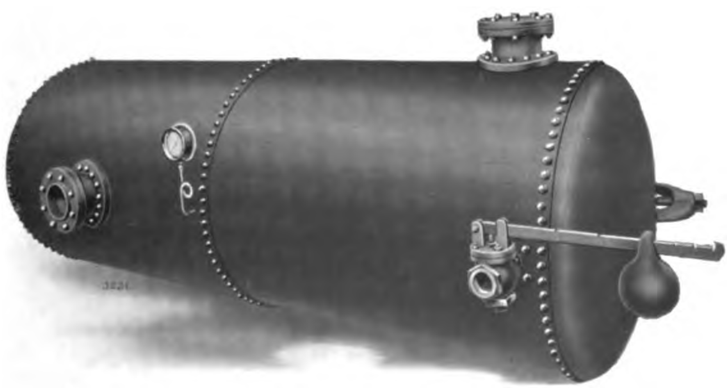
The Ingersoll-Rand Aftercooler consists of a shell or body through which the compressed air from a compressor is circulated over, about and between tubes through which cold water is passing. This reduces the temperature of the air to within a few degrees of the temperature of the water, and this cooling results in the precipitation of most of the moisture contained in the air.

The aftercooler is essentially an air drier and is used in high-grade installations for furnishing dry air for the operation of pneumatic tools, switch and signal work, pumps, air engines, rock drills and other machinery. It has also been used in other special applications of compressed air, such as drying grain or other substances by means of the air jet where it is imperative that the air shall be free from moisture and oil. See Pamphlet 9012 (in preparation).

Air Receivers



The Air Receiver is an essential part of every compressed air installation for any purpose. It is usually placed close to the air compressor and absorbs the pulsations of compressed air delivered by the latter so that a steady flow is supplied to the pipe line. Large installations frequently have several secondary air receivers located throughout the pipe system. The air receiver is in a sense a balance wheel on a compressed air system, absorbing the minor fluctuations of load. The vertical type enjoys the greatest popularity, though the horizontal type is largely used in the smaller sizes as a moisture trap. The Company can furnish all sizes and styles, made of the best 60,000 pounds t.s. steel, strongly riveted, and tested for safety under the pressures for which they are intended. See Pamphlet 9002.

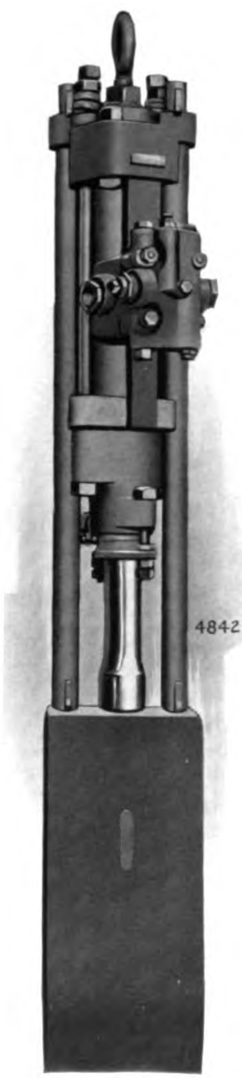


Air Reheaters

The Air Reheater is an economical feature of the compressed air plant often overlooked. Reheating compressed air does one of two things. It either increases the pressure in a given volume, or it increases the volume at a given pressure. In either case there is an increase of power which is secured at a very low cost, viz., that of the fuel used in reheating. The fumes from the reheater necessarily limit its application to open work, such as quarries and contracts. But in this class of work it certainly brings about a very important saving.

The Company offers two types, the "Rand" and the "Sergeant," which are highly efficient and economical in fuel consumption. The former is shown in the upper illustration and the latter in the lower picture. Simplicity is characteristic of both types, which are built for hard service. See Pamphlet 9011 (in preparation).

The "Sergeant" Sheet Pile Driver

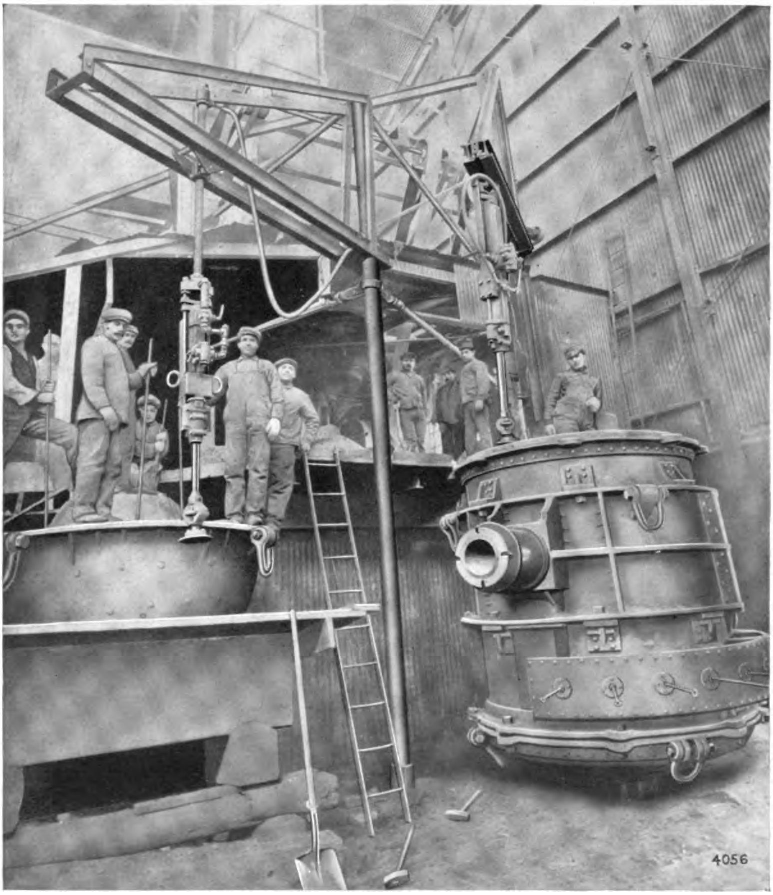


The "Sergeant" Sheet Pile Driver is a modification of one of the Ingersoll-Rand Drill models. Built in the same shops and by the same methods as the drills themselves, it embodies all the care in design, materials and workmanship which have made Ingersoll-Rand rock drills the contractor's and miner's standard of endurance. The machine may be operated by either steam or compressed air.

Its great field is in the driving of sheet piling in contract work, such as sewers, trenches, foundations, docks, caissons and shafts. Its principle of operation is that of a rapid succession of comparatively light blows, so that the piles are pushed rather than driven, in without any injury to the top.

There is no buckling, bushing, splitting or binding of the piles, and no loss of alignment. Where guides for the piling are necessary, they in no way interfere with the operation of the machine and can be made much lighter because of the lighter duty imposed by this pile driver. This device is readily adapted, by means of a special head, to the driving of any of the standard forms of steel interlocking piling.

The pile driver may be suspended by block and tackle from a traveling crane, from an overhead cable-way, or other support; and it is readily handled. Wood piles 12 x 2 to 4 inches in section, up to 25 feet long, are easily handled by this machine. See Pamphlet 9009.



The "Sergeant" Tamping Machine

The "Sergeant" Tamping Machine is a special device developed for tamping in the fire clay lining of the converters used in copper smelters. It is a modified Ingersoll-Rand drill and is furnished with or without a feed screw for raising and lowering. The fire clay or silica lining is rammed in the converter around a metal form or mold. This gives a very hard, compact lining which stands up well under this difficult service; and it does the work of several men in a given time. See Pamphlet 9008 (in preparation).

The "Sergeant" Ticket Canceling Box

The "Sergeant" Ticket Canceling Box has won almost international application in railway, elevated roads, subway and trolley stations, in ferry houses, amusement resorts and other places where great quantities of tickets must be disposed of without possibility of being used a second time. Tickets once dropped in these boxes cannot be removed until they have passed through the chopper which mutilates them beyond all possibility of further use. It has been the one device which has offered a complete solution of this difficult problem and is an absolute protection against loss through the reissuing of tickets. See Pamphlet 9010 (in preparation).

Uses of Compressed Air

The following list is not supposed to cover all possible applications of compressed air, but represents some of the applications which have been met in the Company's experience and for which machines have been applied.

ACID WORKS
Agitating, Elevating and Transferring Acids and Acid Solutions
Pumping Water

ASPHALT REFINERIES
Agitating Asphalt
Scaling Asphalt Tanks or Vats

AGRICULTURAL IMPLEMENT MAKERS
Operating Pneumatic Hammers and Drills
Running Pneumatic Hoists and Lifts
Sand Blast for Cleaning Castings and Removing Paint
Pneumatic Painting and Whitewashing.
Blowing Oil Furnaces
Cleaning Boiler Tubes

AUTOMOBILE GARAGES AND REPAIR SHOPS
Pumping up Tires
Cleaning Engines and Machines by the Air Jet.
Operating Jacks, Lifts and Hoists
Running Pneumatic Hammers, Drills, Reamers, etc.
Cleaning Cars and Cushions with the Air Jet
Operating Brazing Forges
Supplying Oil Burners
Starting Gas and Gasoline Engines

BLEACHERIES
Pumping Water
Handling Chlorine or bleaching Solutions
Agitating Liquids.

BOILER SHOPS
Running Chipping, Riveting and Calking Hammers
Operating Drills, Reamers, Flue Rollers, Flue Expanders, Stay Bolt Cutters, Punches, etc.
Blowing Rivet Forges
Supplying Hoists, Lifts and Jacks
Cleaning Boiler Flues
Removing Scale, Rust and Paint by the Sand Blast

BREWERIES
Pumping Water
Racking Beer
Scaling Condenser Coils
Cleaning Boiler Tubes
Cleaning Machines by the Air Jet
Operating Air Hoists and Lifts
Refrigeration

BRIDGE BUILDERS
Operating Chipping and Riveting Hammers, Drills, Reamers, Punches, etc.
Supplying Air Hoists and Lifts
Blowing Rivet Forges
Cleaning Steel with the Sand Blast
Pneumatic Paint Spraying System

CEMENT BLOCK FACTORIES
Operating Sand Sifters
Running Concrete Rammers
Air Hoists and Lifts

CEMENT LAKES
Pumping Marl or Slurry by the Return-Air System

CEMENT MINES OR QUARRIES
Operating Rock Drills

CHEMICAL WORKS
Pumping Water
Agitating, Aerating, Elevating and Transferring Liquids
Testing and Calking Tanks and Pipe Lines

CHINA WORKS & POTTERIES
Spraying Colors and Enamels

COAL MINES
Operating Coal Punchers, Chain Machines and Radialaxe Coal Cutters

Running Rock Drills and Hammer Drills
Pneumatic Haulage Systems
Return-Air System for Station and Sump Pumping
Operating Direct-Acting Pumps
Running Coal Pick and Drill Sharpeners.
Cleaning Boiler Flues
Pneumatic Tools for the Repair Shop
Air Hoists, Lifts and Motors
Pile Drivers for Shaft Sinking
Air Lift Pump for Water Supply or Mine unwatering

CONTRACT WORK
Running Rock Drills, Hammer Drills and Stone Channelers
Operating Pneumatic Hammers, Drills and Reamers
Calking Pipe Lines and Tanks
Running Pumps
Plug Drills in Trenching
Sheet Pile Drivers
Drill Sharpeners
Blowing Smith Fires
Submarine Drills
Subaqueous Tunneling
Caisson Work
Steam Shovels

COTTON FINISHING WORKS
Pumping Water
Operating Baling Presses
Cleaning Presses, Slashers and other Machines by the Air Jet
Agitating, Elevating and Transferring Dyes and Solutions
Air Hoists, Lifts and Motors
Automatic Sprinkler Systems
Humidifying Systems

COTTON MILLS
Pumping Water
Cleaning Looms, Lifts and Spindle Rails by the Air Jet
Humidifying Systems
Automatic Sprinkler Systems
Air Lifts, Hoists and Motors
Moistening Goods

COTTON OIL MILLS
Cleaning Crusher Rolls and Separator Plates
Air Hoists, Lifts and Motors
Pumping Water
Operating Formers

CREOSOTING PLANTS
Wood Preserving Processes

CUT STONE AND MONUMENTAL YARDS
Running Stone Tools, Polishers, etc.
Lettering and Carving
Cleaning Carvings with the Air Jet
Air Hoists and Lifts
Running Plug Drills and Bush Hammers

DYE WORKS
Pumping Water
Agitating, Elevating and Transferring Dyes

ELECTRIC POWER AND LIGHTING PLANTS
Operating Air Hoists
Cleaning Engines and Generators with the Air Jet
Cleaning Boiler Flues
Calking Boilers

ELECTRIC RAILWAYS
Cleaning Motors and Generators with the Air Jet
Pneumatic Hammers and Drills
Air Hoists, Lifts and Jacks
Blowing Forges
Cleaning Cars by the Air Jet
Pumping Water
Air Brakes
Storage Air Brake Systems
Switch and Signal Systems
Operating Car Doors
Track Sanders
Cleaning Rails by the Sand Blast Preliminary to Electric Welding

ENAMELED IRON WORKS
Blowing or Spraying Enamel

FIRE STATIONS
Blowing Fire Whistles

FLAX MILLS
Pumping Water
Cleaning with the Air Jet
Cleaning Boiler Flues

FOUNDRIES
Operating Sand Rammers and Molding Machines
Pneumatic Hammers and Drills
Pneumatic Sand Sifter
Air Hoists, Lifts and Motors
Cleaning Castings by the Sand Blast
Blowing out Cores
Drilling Salamanders
Aerating Metal in Bessemer Process

GAS WORKS
Starting Gas Engines
Compressing Carbonic Acid
Acetylene, Oxygen and other Gases (Compressors)
Riveting and Calking Tanks
Calking and Testing Pipe Lines
Vaporizing Oil for Oil Engines
High Pressure Gas Transmission (Compressors)

GLASS WORKS
Pumping Glass Sand by the Return-Air System
Blowing Glass
Operating Molds and Presses
Supplying Oil Burners
Operating Sand Blasts
Etching Glass

GRAIN ELEVATORS
Drying Grain

HAT FACTORIES
Operating Presses
Cleaning Machines with the Air Jet

ICE AND REFRIGERATING PLANTS
Pumping and Aerating Water
Air Hoist for Ice Tanks
Air Hoist for Loading Cars
Scaling Condenser Coils
Cleaning Boiler Flues

IRRIGATION
Pumping Water by the Air Lift or Displacement Systems

JUTE MILLS
Pumping Water
Operating Air Hoists, Lifts and Motors

KNITTING MILLS
Pumping Water
Cleaning with the Air Jet
Agitating, Elevating and Transferring Solutions
Automatic Sprinkler Systems
Air Hoists, Lifts and Motors

MACHINE SHOPS
Pumping Water
Operating Pneumatic Hammers and Drills
Supplying Power Hammers, Air Hoists, Lifts and Jacks
Air Motors for Grinding, Buffing, etc.
Sand Blast for Cleaning Metals
Cleaning Machines by the Air Jet
Belt Shifters for Heavy Machine Tools
Punches and Presses
Pipe Bending Machines

MINING
Running Rock Drills and Hammer Drills
Return-Air System for Station and Sump Pumping
Unwatering by the Air Lift System
Air Hoists and Motors
Pneumatic Tools for the Repair Shop
Operating Air Brakes on Hoists
Unloading Cars
Running Direct-Acting Pumps
Drill Steel Sharpeners
Blowing Smith Fires
Oil Furnaces for Steel Sharpeners
Pile Drivers for Shaft Work

MUNICIPALITIES AND PUBLIC INSTITUTIONS
Pumping Water by the Air Lift or Return-Air System
Pumping Sewage
Testing and Calking Pipe Lines
Rock Drills in Road Construction
Blowing Fire Whistles
Filtration Plants

OFFICE BUILDINGS AND HOTELS
Sewage and Drainage Ejectors
Pneumatic Clocks
Operating Elevator Doors
Cleaning with the Air Jet
Dentist, Physician and Barber Service
Accumulator Systems

OIL REFINERIES
Displacing and Transferring Oil
Agitating and Transferring Acids
Pneumatic Hammers and Drills
Calking Tanks and Pipe Lines
Air Hoists and Lifts
Oil Wells
Pumping by the Air Lift or Displacement Systems

PACKING HOUSE PLANTS
Pumping Water

Stuffing Sausages
Operating Belly Pounders
Lard Refineries
Air Hosts, Lifts and Motors

PAINT FACTORIES
Dressing Burr Stones
Agitating and Transferring Mixtures
Air Hoists and Lifts

PRINTING SHOPS
Monotype Machines
Air Hoists and Lifts
Cleaning by the Air Jet

QUARRIES
Rock Drills, Hammer Drills and Plug Drills
Stone Channelers
Air Hoists, Lifts and Motors
Drainage Pumping by the Return-Air System
Operating Direct-Acting Pumps
Splitting Stone in the Bed.

RAILROADS
Starting Fires in Locomotives
Operating Pneumatic Hammers and Drills
Cleaning Flues
Calking Boilers and Tanks
Air Hoists, Lifts and Jacks
Air Brakes
Turn-Table Motors
Crossing Gates
Switch and Signal Systems
Sand Blast for Removing Paint, Cleaning Castings, etc.
Pneumatic Sand Rammers
Paint and Whitewash Spraying
Cleaning Cars, Furnishings, etc.
Transferring Oil
Pumping Water
Track Sander
Valve Setting Machines

ROAD BUILDING
Running Rock Drills and Plug Drills

RUBBER FACTORIES
Testing Rubber
Inflating Rubber Tires
Testing Tires, etc.
Air Hoists, Lifts and Motors

SALT MINES
Rock Drills and Plug Drills

SALT WELLS
Pumping Brine

SAND PITS
Pumping Sand by the Return-Air System

SAW MILLS
Operating Edgers, Bumpers, Pick-ups, etc.
Blowing Sawdust and Shavings from Machines
Pneumatic Haulage
Pumping Water
Automatic Sprinkler Systems

SEWAGE & TRENCH WORK
Rock Drills and Hammer Drills
Sheet Pile Drivers
Calking and Testing Pipe Lines

SHIPYARDS AND BOAT BUILDERS
Pneumatic Hammers and Drills
Air Hoists, Lifts and Motors
Cleaning Plates and Castings by the Sand Blast
Pneumatic Painting
Starting Gasoline Engines
Riveting and Calking

SMELTERS AND ORE MILLS
Converter Tamping Machines
Air Hoists and Lifts
Blowing Converters
Agitating Cyanide Solution
Cleaning Cyanide Tanks by the Sand Blast
Calking Tanks
Handling Solutions

STEAM POWER PLANTS
Cleaning Boiler Flues
Calking Boilers
Pumping Water
Air Hoists and Lifts

STORE SERVICE
Pneumatic Cash Carriers
Cleaning by the Air Jet

STRUCTURAL WORKS
Pneumatic Tools for Drilling, Reaming, Chipping, Scaling, Riveting and Calking
Air Hoists
Pneumatic Punches
Rock Drills and Plug Drills
Drainage Pumps

SUGAR REFINERIES
Agitating and Transferring Syrups
Pumping Water
Air Hoists and Lifts
Pressure Filters

TANNERIES
Pumping Water
Handling Tan Liquid
Air Hoists and Lifts

THEATRES AND HALLS
Cleaning with the Air Jet
Displacing Water
Handling Scenery with the Air Hoist and Lift

U.S. GOVERNMENT
Pneumatic Tube Systems
Torpedo Charging
Ammunition Hoists
Pumping Water
Sand Blasts

WAREHOUSES AND STORAGE
Air Hoists and Lifts
Air Motors
Air Cleaning

WATCH FACTORIES
Blowing Dust, Chips, etc., with the Air Jet
Pneumatic Tools
Air Hoists and Motors

WATER WORKS
Pumping Water
Cleaning Boiler Flues
Calking Boilers and Tanks
Calking and Testing Pipe Lines
Sheet Pile Drivers
Plug Drills and Rock Drills for Trenching

WOODWORKING MILLS
Bending Wood

WOOLEN MILLS
Pumping Water
Agitating and Handling Dyes and Solutions
Cleaning Looms, Doffers and Spindles
Air Motors, Hoists and Lifts
Pressure Accumulators
Starting Gas and Gasoline Engines

I. WEIGHT OF AIR AT VARIOUS PRESSURES AND TEMPERATURES

BASED ON AN ATMOSPHERIC PRESSURE OF 14.7 POUNDS ABSOLUTE AT SEA LEVEL

Temperature of Air, Deg. Fahr.	GAGE PRESSURE, POUNDS																				
	0	5	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	175	200	225	250	300
	WEIGHT IN POUNDS PER CUBIC FOOT																					
−20	.0900	.1205	.1515	.2125	.2744	.3360	.3970	.4580	.5190	.5800	.6410	.702	.7635	.825	.886	.948	1.010	1.165	1.318	1.465	1.625	1.930
−10	.0882	.1184	.1485	.2090	.2685	.3283	.3880	.4478	.5076	.5674	.6272	.687	.747	.807	.868	.928	.989	1.139	1.288	1.438	1.588	1.890
0	.0864	.1160	.1455	.2040	.2630	.3215	.3800	.4385	.4970	.5555	.6140	.672	.731	.790	.849	.908	968	1.114	1.260	1.406	1.553	1.850
10	.0846	.1136	.1425	.1995	.2568	.3145	.3720	.4292	.4863	.5433	.6006	.658	.716	.774	.832	.889	.947	1.090	1.233	1.376	1.520	1.810
20	.0828	.1112	.1395	.1955	.2516	.3071	.3645	.4205	.4770	.5330	.5890	.645	.701	.757	.813	.869	.927	1.067	1.208	1.348	1.489	1.770
30	.0811	.1088	.1366	.1916	.2465	.3015	.3570	.4121	.4672	.5221	.5771	.632	.687	.742	.797	.852	.908	1.046	1.184	1.322	1.460	1.735
40	.0795	.1067	.1338	.1876	.2415	.2954	.3503	.4038	.4576	.5114	.5652	.619	.673	.727	.781	.835	.890	1.025	1.161	1.296	1.431	1.701
50	.0780	.1045	.1310	.1839	.2367	.2905	.3432	.3960	.4487	.5014	.5541	.607	.660	.713	.766	.819	.873	1.006	1.139	1.271	1.403	1.668
60	.0764	.1025	.1283	.1803	.2323	.2840	.3562	.3882	.4402	.4927	.5447	.596	.649	.700	.752	.804	.856	.988	1.116	1.245	1.376	1.636
70	.0750	.1005	.1260	.1770	.2280	.2791	.3302	.3808	.4316	.4824	.5332	.584	.635	.686	.737	.788	.839	.967	1.095	1.223	1.350	1.604
80	.0736	.0988	.1239	.1738	.2237	.2739	.3242	.3738	.4234	.4729	.5224	.572	.622	.673	.723	.774	.824	.949	1.074	1.199	1.325	1.573
90	.0723	.0970	.1218	.1707	.2195	.2688	.3182	.3670	.4154	.4639	.5122	.561	.611	.660	.709	.759	.809	.932	1.054	1.177	1.300	1.544
100	.0710	.0954	.1197	.1676	.2155	.2638	.3122	.3602	.4079	.4555	.5033	.551	.599	.648	.696	.745	.794	.914	1.035	1.155	1.276	1.517
110	.0698	.0937	.1176	.1645	.2115	.2593	.3070	.3542	.4011	.4481	.4950	.542	.589	.637	.685	.732	.780	.899	1.017	1.135	1.254	1.491
120	.0686	.0921	.1155	.1618	.2080	.2549	.3018	.3481	.3944	.4403	.4866	.533	.579	.626	.673	.720	.767	.884	1.001	1.118	1.234	1.465
130	.0674	.0905	.1135	.1590	.2045	.2505	.2966	.3446	.3924	.4296	.4770	.524	.570	.616	.662	.708	.754	.869	.984	1.099	1.214	1.440
140	.0663	.0889	.1115	.1565	.2015	.2465	.2915	.3364	.3813	.4262	.4711	.516	.561	.606	.651	.696	.742	.855	.968	1.081	1.194	1.416
150	.0652	.0874	.1096	.1541	.1985	.2425	.2865	.3308	.3751	.4193	.4636	.508	.552	.596	.640	.685	.730	.841	.953	1.064	1.175	1.392
175	.0626	.0840	.1054	.1482	.1910	.2335	.2755	.3181	.3607	.4033	.4450	.488	.531	.573	.616	.658	.701	.808	.914	1.021	1.128	1.337
200	.0603	.0809	.1014	.1427	.1840	.2248	.2655	.3054	.3473	.3882	4291	.470	.511	.552	.592	.633	.674	.776	.879	.982	1.084	1.287
225	.0581	.0779	.0976	.1373	.1770	.2163	.2555	.2949	.3344	.3738	.4129	.452	.491	.531	.570	.609	.649	.747	.846	.944	1.043	1.240
250	.0560	.0751	.0941	.1323	.1705	.2085	.2466	.2845	.3223	.3602	.3981	.436	.474	.513	.551	.589	.627	.722	.817	.912	1.007	1.197
275	.0541	.0726	.0910	.1278	.1645	.2011	.2378	.2745	.3111	.3478	.3844	.421	.458	.494	.531	.568	.605	.697	.789	.881	.972	1.155
300	.0523	.0707	.0881	.1237	.1592	.1945	.2300	.2654	.3008	.3362	.3716	.407	.442	.478	.513	.549	.585	.673	.762	.852	.940	1.118
350	.0491	.0658	.0825	.1160	.1495	.1828	.2160	.2492	.2824	.3156	.3488	.382	.415	.449	.482	.516	.549	.632	.715	.799	.883	1.048
400	.0463	.0621	.0779	.1090	.1405	.1720	.2035	.2348	.2661	.2974	.3287	.360	.391	.423	.454	.486	.517	.596	.674	.753	.831	.987
450	.0437	.0586	.0735	.1033	.1330	.1628	.1925	.2220	.2515	.2810	.3105	.340	.369	.399	.429	.458	.488	.562	.637	.711	.786	.934
500	.0414	.0555	.0696	.0978	.1260	.1540	.1820	.2100	.2380	.2660	.2940	.322	.351	.379	.407	.435	.463	.534	.604	.675	.746	.885
550	.0394	.0528	.0661	.0930	.1198	.1464	.1730	.1996	.2262	.2528	.2794	.306	.333	.359	.386	.413	.440	.507	.573	.641	.709	.841
600	.0376	.0504	.0631	.0885	.1140	.1395	.1650	.1904	.2158	.2412	.2668	.292	.317	.343	.368	.393	.419	.483	.547	.611	.675	.801

II. DENSITY OF GASES AND VAPORS*

COMPARED WITH AIR AT SAME TEMPERATURE AND PRESSURE; ALSO WEIGHT OF A CUBIC FOOT AT 62° F. UNDER ATMOSPHERIC PRESSURE OF 14.7 LBS. ABS. OR 29.92 INCHES MERCURY

	Density. Air at Same Temp. and Pres. being 1.0 (Regnault)	Specific Gravity or Density. Water at 62° being 1.0	Weight of a Cubic Foot in Pounds	Cubic Feet at 62° in One Pound
Air (atmospheric).........	1.00000	.001221 or $\frac{1}{819}$	.07610	13.14
Hydrogen gas............	.06926	.0000846 or $\frac{1}{11820}$	.00527	189.70
Oxygen gas..............	1.10563	.001350 or $\frac{1}{741}$	.08414	11.88
Nitrogen gas............	.97137	.001185 or $\frac{1}{844}$	.07383	13.54
Carbonic acid gas.........	1.52901	.001870 or $\frac{1}{535}$	.11636	8.59
Carbonic oxide gas........	.9674	.00118 or $\frac{1}{847}$	.07364	13.60
Vapor of water...........	.6235	.0007613 or $\frac{1}{1313}$	.04745	21.07
Vapor of alcohol..........	1.589	.00194 or $\frac{1}{515}$	.12092	8.27
Vapor of sulphuric ether...	2.586	.00316 or $\frac{1}{316}$	.19680	5.08
Vapor of oil of turpentine.	4.760	.00581 or $\frac{1}{172}$	.36224	2.76
Vapor of mercury........	6.976	.00850 or $\frac{1}{118}$	.52987	1.88

*From "Practical Treatise on Heat," by Thomas Box.

III. EFFECT OF INITIAL OR INTAKE TEMPERATURE ON EFFICIENCY AND CAPACITY OF AIR COMPRESSORS

UNIT CAPACITY AND EFFICIENCY ASSUMED AT 60° F.

Initial Temperature		Relative Capacities and Efficiencies	Initial Temperature		Relative Capacities and Efficiencies
Degrees Fahr.	Degrees Abs.		Degrees Fahr.	Degrees Abs.	
-20	441	1.18	70	531	.980
-10	451	1.155	80	541	.961
0	461	1.13	90	551	.944
10	471	1.104	100	561	.928
20	481	1.083	110	571	.912
30	491	1.061	120	581	.896
32	493	1.058	130	591	.880
40	501	1.040	140	601	.866
50	511	1.020	150	611	.852
60	521	1.000	160	621	.838

IV. DISPLACEMENT IN CUBIC FEET PER MINUTE, PISTON WORKING IN SINGLE CYLINDER AT VARIOUS PISTON SPEEDS

Diam. of Cylinder Inches	PISTON SPEED, FEET PER MINUTE																	
	100	150	200	225	250	275	300	325	350	375	400	425	450	475	500	550	600	700
3	4.9	7.4	9.8	11.1	12.3	13.5	14.7	16	17.2	18.5	19.6	21	22.2	23.4	24.6	27	29.4	34.4
4	8.7	13.1	17.4	19.7	21.8	24	26.2	28.5	30.7	32.9	34.8	37.2	39.4	41.5	43.6	48	52.4	61.4
5	13.6	20.5	27.2	30.8	34.2	37.5	41	44.5	48	51.4	54.4	58	61.6	65	68.4	75	82	96
6	19.6	29.5	39.2	44.4	49	54	59	64	69	74	78.4	84	88.8	93	98	108	118	138
7	26.7	40	53.4	60.5	67	74	80	87	94	100.6	106.8	114	121	127	134	148	160	188
8	35	52.5	70	79	87.5	96	105	114	123	132	140	149	158	166	175	192	210	246
9	44	66.5	88	100	110	122	133	144	155	166	176	188	200	210	220	244	266	310
10	54.5	82	109	123	136	150	164	178	192	206	218	233	246	260	272	300	328	384
11	66	99	132	149	165	182	198	215	232	250	264	282	298	315	330	364	396	464
12	78	118	156	177	196	216	236	256	276	296	312	335	354	374	392	432	472	552
13	92	138	184	208	230	255	276	300	325	345	368	392	416	440	460	510	552	650
14	106	160	212	240	266	295	320	348	375	400	424	455	480	510	532	590	640	750
15	122	184	244	276	305	337	368	400	432	460	488	521	552	580	610	674	736	864
16	139	210	278	315	350	385	420	455	490	525	556	595	630	660	700	790	840	980
17	157	236	314	355	395	435	472	512	550	509	628	672	710	750	790	870	944	1100
18	176	265	352	400	440	485	530	575	620	660	704	755	800	840	880	970	1060	1240
19	196	295	392	445	490	540	590	640	690	740	784	840	890	930	980	1080	1180	1380
20	218	328	436	490	545	600	656	710	765	820	872	930	980	1040	1090	1200	1312	1530
22	265	395	530	595	660	725	790	860	930	990	1060	1120	1190	1260	1320	1450	1580	1860
24	314	470	628	710	790	865	940	1020	1100	1180	1256	1340	1420	1500	1580	1730	1880	2200
26	369	550	738	830	920	1020	1100	1200	1300	1390	1476	1570	1660	1750	1840	2040	2200	2600
28	427	640	854	960	1070	1180	1280	1390	1500	1600	1780	1820	1920	2030	2140	2360	2560	3000
30	490	740	980	1110	1230	1350	1480	1600	1720	1840	1960	2100	2220	2340	2460	2700	2960	3440
32	560	835	1120	1260	1400	1540	1670	1820	1960	2100	2240	2380	2520	2660	2800	3080	3340	3920
34	630	945	1260	1420	1570	1740	1890	2050	2220	2360	2520	2690	2840	3000	3140	3480	3780	4440
36	710	1060	1420	1600	1770	1950	2120	2300	2500	2650	2840	3000	3200	3360	3540	3900	4240	5000
38	780	1180	1560	1780	1960	2170	2360	2560	2750	2950	3120	3350	3560	3750	3920	4340	4720	5500
40	870	1310	1740	1970	2180	2400	2620	2850	3060	3280	3480	3720	3940	4150	4360	4800	5240	6120

V. HORSE-POWER, EFFICIENCY AND TERMINAL TEMPERATURE IN AIR COMPRESSION TO VARIOUS PRESSURES

SINGLE AND TWO STAGE COMPRESSION

Gage Pressures	Atmospheres	Isothermal Compression	Single Stage Adiabatic Compression			Two Stage Compression		
		H.P. required to Compress One Cubic Foot per Minute	H.P. required to Compress One Cubic Foot Free Air per Minute	Efficiency as compared to Isothermal	Final Temperature Degrees Fahr. Perfect Intercooling Adiabatic Compression	H.P. required to Compress One Cubic Foot Free Air per Minute	Efficiency as compared to Isothermal	Final Temperature Degrees Fahr. Perfect Intercooling Adiabatic Compression
5	1.34	.0188	.0197	.96	106			
10	1.68	.0333	.0362	.93	145			
15	2.02	.0481	.0505	.90	178			
20	2.36	.0551	.0630	.88	207			
25	2.70	.0638	.075	.85	234			
30	3.04	.0713	.085	.84	252			
40	3.72	.0843	.104	.81	302			
50	4.40	.0948	.120	.79	339	.109	.87	188
60	5.08	.1037	.134	.77	375	.121	.86	203
70	5.76	.1120	.148	.75	405	.131	.85	214
80	6.44	.1196	.160	.74	432	.141	.85	224
90	7.12	.1260	.171	.74	459	.150	.84	234
100	7.80	.1320	.182	.73	485	.158	.83	243
110	8.48	.1371	.192	.72	500	.165	.83	250
120	9.16	.1422	.202	.71	529	.172	.83	257
130	9.84	.1467	.210	.70	560	.179	.82	265
140	10.52	.1510	.218	.69	570	.186	.82	272
150	11.20	.1547	.226	.69	589	.193	.81	279
160	11.88	.1583	.234	.68	607	.198	.81	285
180	13.24	.1656	.249	.67	640	.208	.80	297
200	14.60	.1720	.263	.65	672	.217	.79	309
225	16.3	.1790	.278	.64	715	.227	.79	320
250	18.	.1860	.292	.64	749	.237	.78	331
275	19.7	.1920	.306	.63	780	.247	.78	342
300	21.4	.1970	.317	.62	815	.256	.77	352
350	24.8	.2060	.342	.60	867	.272	.76	370
400	28.2	.2140	.364	.59	915	.283	.76	380
450	31.6	.2230	.381	.58	960	.295	.75	397
500	35.	.2290	.398	.57	1000	.307	.75	415
550	38.4	.2340	.416	.56	1040	.321	.73	430
600	41.8	.240	.432	.55	1077	.332	.72	442
650	45.2	.245	.447	.55	1113	.345	.71	451
700	48.6	.249	.461	.54	1136	.355	.70	458
750	52.	.252	.475	.53	1178	.363	.69	462
800	55.4	.258	.488	.52	1208	.373	.69	468
850	58.8	.262	.500	.52	1237	.381	.69	480
900	62.2	.265	.512	.52	1265	.388	.68	490
950	65.6	.268	.523	.51	1292	.395	.68	495
1000	69.	.272	.534	.51	1318	.403	.67	498
1100	75.8	.278	.555	.50	1367	.416	.67	507
1200	82.6	.283	.575	.49	1415	.429	.66	525
1300	89.4	.289	.594	.49	1457	.441	.66	534
1400	96.2	.293	.611	.48	1498	.452	.65	550
1500	103.	.297	.627	.48	1537	.462	.65	563
1600	109.8	.301	.643	.47	1575	.472	.64	568
1700	116.6	.305	.659	.47	1610	.482	.63	589
1800	123.4	.309	.673	.46	1645	.491	.63	606
1900	130.2	.313	.687	.46	1678	.500	.63	628
2000	139.	.317	.701	.45	1709	.509	.62	639
2250	154.	.324	.733	.44	1784	.528	.62	645
2500	171.	.331	.763	.43	1852	.547	.61	654
3000	205.	.342	.816	.42	1975	.579	.59	670

VI. HORSE-POWER, EFFICIENCY AND TERMINAL TEMPERATURE IN AIR COMPRESSION TO VARIOUS PRESSURES

THREE AND FOUR STAGE COMPRESSION

Gage Pressures	Atmospheres	Isothermal Compression	Three Stage Compression			Four Stage Compression		
		H.P. required to Compress One Cubic Foot per Minute	H.P. required to Compress One Cubic Foot Free Air per Minute	Efficiency as compared to Isothermal	Final Temperature Degrees Fahr. Perfect Intercooling Adiabatic Compression	H.P. required to Compress One Cubic Foot Free Air per Minute	Efficiency as compared to Isothermal	Final Temperature Degrees Fahr. Perfect Intercooling Adiabatic Compression
5	1.34	.0188						
10	1.68	.0333						
15	2.02	.0481						
20	2.36	.0551						
25	2.70	.0638						
30	3.04	.0713						
40	3.72	.0843						
50	4.40	.0948						
60	5.08	.1037						
70	5.76	.1120						
80	6.44	.1196						
90	7.12	.1260						
100	7.80	.1320						
110	8.48	.1371						
120	9.16	.1422						
130	9.84	.1467						
140	10.52	.1510						
150	11.20	.1547	.182	.85	200			
160	11.88	.1583	.187	.85	204			
180	13.24	.1656	.197	.84	211			
200	14.60	.1720	.206	.83	218			
225	16.3	.1790	.215	.83	224			
250	18.	.1860	.224	.83	230			
275	19.7	.1920	.233	.82	236			
300	21.4	.1970	.241	.82	241			
350	24.8	.2060	.252	.82	250			
400	28.2	.2140	.262	.82	258			
450	31.6	.2230	.272	.82	266			
500	35.	.2290	.282	.81	275	26.	.88	215
550	38.4	.2340	.292	.80	283	26.9	.87	220
600	41.8	.240	.300	.80	290	27.8	.86	225
650	45.2	.245	.310	.79	295	28.4	.86	228
700	48.6	.249	.320	.78	300	29.	.86	234
750	52.	.252	.327	.78	305	29.6	.85	236
800	55.4	.258	.334	.78	309	30.2	.85	240
850	58.8	.262	.341	.77	314	30.7	.85	244
900	62.2	.265	.347	.76	319	31.2	.85	247
950	65.6	.268	.354	.76	322	31.6	.85	250
1000	69.	.272	.360	.75	325	32.	.85	252
1100	75.8	.278	.370	.75	331	32.7	.85	254
1200	82.6	.283	.381	.74	338	33.4	.84	258
1300	89.4	.289	.390	.74	342	34.1	.84	265
1400	96.2	.293	.399	.74	349	34.8	.84	270
1500	103.	.297	.406	.73	353	35.5	.84	273
1600	109.8	.301	.415	.73	358	36.1	.83	276
1700	116.6	.305	.424	.72	364	36.7	.83	280
1800	123.4	.309	.431	.72	370	37.2	.83	284
1900	130.2	.313	.438	.72	374	37.7	.83	287
2000	139.	.317	.444	.71	378	38.1	.83	290
2250	154.	.324	.460	.70	385	39.3	.82	294
2500	171.	.331	.474	.70	398	40.5	.82	298
3000	205	.342	.500	.69	414	42.	.81	308

VII. LOSS OF WORK DUE TO HEAT IN COMPRESSING AIR FROM ATMOSPHERIC PRESSURE TO VARIOUS GAGE PRESSURES BY SIMPLE AND COMPOUND COMPRESSION

AIR IN EACH CYLINDER; INITIAL TEMPERATURE 60° F.

Gage Pressure	One Stage		Two Stage		Three Stage		Four Stage	
	Percentage of Work Lost in Terms of							
	Isothermal Compression	Adiabatic Compression	Isothermal Compression	Adiabatic Compression	Isothermal Compression	Adiabatic Compression	Isothermal Compression	Adiabatic Compression
60	29 9	23.0	13.4	11.8	8.6	7.9	4.7	4.5
70	30 6	23.4	14.1	12.4	8.7	8.0	6.1	5.7
80	32.7	24.6	14.7	12.8	9.7	8.9	6.4	6.0
90	34.7	25.8	16.1	13.8	10.5	9.5	7.3	6.8
100	36.7	26.8	16.9	14.5	10.9	9.8	7.8	7.3
125	41.1	29.2	18.5	15.6	11.6	10.4	8.8	8.1
150	44.8	30.9	20.1	16.7	12.3	10.9	9.1	8.4
200	51.2	33.9	22.2	18.1	14.0	12.3	10.5	9.5
300	61.2	37.9	25.7	20.5	16.6	14.2	12.0	10.7
400	68.7	40.7	28.9	22.4	18.2	15.4	13.1	11.5
500	70.6	41.4	31.2	23.8	19.3	16.2	14.1	12.3
600	80.4	44.5	32.8	24.7	20.4	16.9	14.9	13.0
700	85 0	46.0	34.6	25.7	21.3	17.6	16.1	13.8
800	89.5	47.2	35.7	26.3	22.0	18.1	16.2	13.9
900	93.0	48.2	37.1	27.0	22.6	18.5	16.6	14.4
1000	96.1	49.0	37.9	27.5	23.2	18.8	16.9	14.5
1200	102 8	50.7	40.3	28.8	24.8	19.9	17.7	15.0
1400	108.6	52.0	41.5	29.3	25.9	20.5	18.6	15.7
1600	113.4	53.1	43.5	30.3	26.5	20.9	19.2	16.1
1800	117.5	54.0	44.8	31.0	27.3	21.2	19.6	16.4
2000	122.0	55 0	45.8	31.4	27.5	21.5	19.9	16.5

E. F. SCHAEFER.

VIII. MULTIPLIERS FOR DETERMINING THE VOLUME OF FREE AIR

AT VARIOUS ALTITUDES WHICH, WHEN COMPRESSED TO VARIOUS PRESSURES, IS EQUIVALENT IN EFFECT TO A GIVEN VOLUME OF FREE AIR AT SEA LEVEL

Altitude in Feet	Barometric Pressure		Multiplier				
	Inches of Mercury	Pounds per Sq. Inch	Gage Pressure (Pounds)				
			60	80	100	125	150
0	30.00	14.75	1.000	1.000	1.000	1.000	1.000
1000	28.88	14.20	1.032	1.033	1.034	1.035	1.036
2000	27.80	13.67	1.064	1.066	1.068	1.071	1.072
3000	26.76	13.16	1.097	1.102	1.105	1.107	1.109
4000	25.76	12.67	1.132	1.139	1.142	1.147	1.149
5000	24.79	12.20	1.168	1.178	1.182	1.187	1.190
6000	23.86	11.73	1.206	1.218	1.224	1.231	1.234
7000	22.97	11.30	1.245	1.258	1.267	1.274	1.278
8000	22.11	10.87	1.287	1.300	1.310	1.319	1.326
9000	21.29	10.46	1.329	1.346	1.356	1.366	1.374
10000	20.49	10.07	1.373	1.394	1.404	1.416	1.424

IX. HORSE-POWER DEVELOPED, WITH ALLOWANCE FOR USUAL LOSSES

IN COMPRESSING ONE CUBIC FOOT OF FREE AIR AT VARIOUS ALTITUDES FROM ATMOSPHERIC TO VARIOUS PRESSURES

Initial Temperature of the Air in Each Cylinder Taken as 60° F. (Jacket Cooling Not Considered)

Altitude in Feet	Horse-Power Developed							
	Simple Compression			Two Stage Compression				
	Gage Pressure (Pounds)			Gage Pressure (Pounds)				
	60	80	100	60	80	100	125	150
0	.1533	.1824	.2075	.1354	.1580	.1765	.1964	.2138
1000	.1511	.1795	.2040	.1332	.1553	.1734	.1926	.2093
2000	.1489	.1766	.2006	.1310	.1524	.1700	.1887	.2048
3000	.1469	.1739	.1971	.1286	.1493	.1666	.1848	.2003
4000	.1448	.1712	.1939	.1263	.1464	.1635	.1810	.1963
5000	.1425	.1685	.1906	.1241	.1438	.1600	.1772	.1921
6000	.1402	.1656	.1872	.1218	.1409	.1566	.1737	.1879
7000	.1379	.1628	.1839	.1197	.1383	.1536	.1700	.1838
8000	.1358	.1600	.1807	.1173	.1358	.1504	.1662	.1797
9000	.1337	.1572	.1774	.1151	.1329	.1473	.1627	.1758
10000	.1316	.1547	.1743	.1132	.1303	.1442	.1592	.1717

EXAMPLE. — Required the volume of free air which, when compressed to 100 pounds gage at 9,000 feet altitude, will be equivalent to 1,000 cubic feet of free air at sea level; also the power developed in compressing this volume to 100 pounds gage in two stage compression at this altitude.

From Table VIII, we find the multiplier in this case to be 1.356. The equivalent free air volume is thus, 1,000 × 1.356 = 1,356 cubic feet.

From Table IX, we find the power developed in compressing 1 cubic foot of free air under these conditions to be .1473 horse-power; 1,356 × .1473 = 199.73 horse-power.

X. EFFICIENCIES OF AIR COMPRESSION AT DIFFERENT ALTITUDES

Altitude Feet	Barometric Pressure		Volumetric Efficiency Compressor Per Cent	Loss of Capacity Per Cent	Decreased Power Required Per Cent
	Inches Mercury	Pounds per Square Inch			
0	30 00	14.75	100	0	0.
1000	28.88	14.20	97	3	1.8
2000	27 80	13.67	93	7	3.5
3000	26.76	13.16	90	10	5.2
4000	25.76	12.67	87	13	6.9
5000	24.79	12.20	84	16	8.5
6000	23.86	11.73	81	19	10.1
7000	22.97	11.30	78	22	11.6
8000	22.11	10.87	76	24	13.1
9000	21.29	10.46	73	27	14.6
10000	20.49	10.07	70	30	16.1
11000	19.72	9.70	68	32	17.6
12000	18.98	9.34	65	35	19.1
13000	18.27	8.98	63	37	20.6
14000	17.59	8.65	60	40	22.1
15000	16.93	8.32	58	42	23.5

XI. GLOBE VALVES, TEES AND ELBOWS

The reduction of pressure produced by globe valves is the same as that caused by the following additional lengths of straight pipe, as calculated by the formula:

$$\text{Additional length of pipe} = \frac{114 \times \text{diameter of pipe}}{1 + (3.6 \div \text{diameter})}$$

Diameter of pipe / Additional length										
Diameter of pipe	1	1½	2	2½	3	3½	4	5	6	inches
Additional length	2	4	7	10	13	16	20	28	36	feet
	7	8	10	12	15	18	20	22	24	inches
	44	53	70	88	115	143	162	181	200	feet

The reduction of pressure produced by elbows and tees is equal to two-thirds of that caused by globe valves The following are the additional lengths of straight pipe to be taken into account for elbows and tees. For globe valves multiply by $\frac{3}{2}$:

Diameter of pipe / Additional length										
Diameter of pipe	1	1½	2	2½	3	3½	4	5	6	inches
Additional length	2	3	5	7	9	11	13	19	24	feet
	7	8	10	12	15	18	20	22	24	inches
	30	35	47	59	77	96	108	120	134	feet

These additional lengths of pipe for globe valves, elbows and tees must be added in each case to the actual length of straight pipe. Thus a 6-inch pipe, 500 feet long, with 1 globe valve, 2 elbows and 3 tees, would be equivalent to a straight pipe 500 + 36 + (2 × 24) + (3 × 24) = 656 feet long.

COMPRESSED AIR TRANSMISSION

LOSS OF PRESSURE IN POUNDS BY FRICTION IN 1000 FEET LENGTHS OF PIPE

Size Pipe	XII DELIVERY IN CUBIC FEET OF COMPRESSED AIR PER MINUTE AT 60 LBS. GAGE																									
	9.84	14.73	19.64	24.60	29.45	34.44	39.35	49.20	58.90	68.6	78.6	88.4	98.4	118.1	137.5	156.6	176.5	196.4	294.5	393.7	492	589	686	786	884	984
	EQUIVALENT DELIVERY IN CUBIC FEET OF FREE AIR PER MINUTE																									
	50	75	100	125	150	175	200	250	300	350	400	450	500	600	700	800	900	1000	1500	2000	2500	3000	3500	4000	4500	5000
1″	18.24																									
1¼″	5.06	11.34	20.16																							
1½″	1.95	4.33	7.79	12.23	17.53																					
2″	.42	.95	1.69	2.65	3.80	5.17	6.77	10.61	15.20																	
2½″	.13	.29	.52	.81	1.16	1.58	2.09	3.24	4.65	6.31	8.28	10.47														
3″	.05	.11	.19	.30	.44	.59	.78	1.22	1.78	2.37	3.11	3.94	4.88	7.03	9.52											
3½″		.05	.08	.13	.19	.26	.36	.55	.78	1.07	1.40	1.77	2.20	3.17	4.29	5.57	7.08	8.77								
4″			.04	.07	.09	.13	.17	.27	.38	.53	.69	.88	1.08	1.56	2.12	2.75	3.49	4.33	9.73							
4½″				.03	.05	.07	.09	.15	.21	.29	.39	.48	.60	.87	1.17	1.52	1.94	2.40	5.39	9.65						
5″					.03	.04	.06	.08	.12	.17	.22	.28	.34	.49	.67	.87	1.17	1.37	3.08	5.51	8.61					
6″						.01	.02	.03	.05	.06	.08	.11	.14	.19	.27	.34	.43	.54	1.20	2.16	3.36	4.82	6.54			
7″							.01	.01	.02	.03	.04	.05	.06	.09	.12	.15	.19	.24	.55	.98	1.53	2.19	2.97	3.91	4.94	6.19
8″									.01	.01	.01	.02	.03	.04	.06	.08	.09	.12	.27	.41	.77	1.11	1.50	1.98	2.51	3.10
9″												.01	.01	.02	.03	.04	.05	.06	.15	.27	.42	.61	.83	1.08	1.36	1.69
10″														.01	.02	.03	.03	.04	.09	.16	.25	.36	.48	.63	.79	.99
12″																.01	.01	.02	.03	.06	.09	.14	.19	.25	.32	.39
14″																		.01	.01	.03	.04	.06	.09	.11	.15	.18
16″																				.01	.02	.03	.04	.05	.07	.09

Size Pipe	XIII DELIVERY IN CUBIC FEET OF COMPRESSED AIR PER MINUTE AT 80 LBS. GAGE																									
	7.74	11.3	15.2	19.4	23.2	27.2	31.0	38.7	46.5	54.2	62.0	69.7	77.4	92.9	108.2	124.0	139.5	152	232	310	387	465	542	620	697	774
	EQUIVALENT DELIVERY IN CUBIC FEET OF FREE AIR PER MINUTE																									
	50	75	100	125	150	175	200	250	300	350	400	450	500	600	700	800	900	1000	1500	2000	2500	3000	3500	4000	4500	5000
1″	14.31																									
1¼″	3.96	8.46	15.31																							
1½″	1.53	3.26	5.92	9.64	13.79																					
2″	.33	.71	1.28	2.09	2.99	4.09	5.34	8.32	12.01																	
2½″	.10	.21	.39	.64	.91	1.25	1.63	2.54	3.67	4.99	6.53	8.25	10.81													
3″	.03	.08	.14	.24	.34	.47	.61	.96	1.38	1.88	2.45	3.13	3.83	5.61	7.46	9.86										
3½″	.01	.03	.06	.11	.15	.21	.27	.43	.62	.84	1.11	1.40	1.73	2.46	3.37	4.42	5.61	6.64	15.41							
4″		.01	.03	.05	.07	.10	.13	.21	.30	.41	.54	.69	.85	1.22	1.66	2.18	2.77	3.29	7.62	13.62						
4½″			.02	.03	.04	.06	.07	.12	.17	.23	.30	.38	.47	.68	.92	1.19	1.54	1.82	4.24	7.58	11.79					
5″			.01	.01	.02	.03	.04	.07	.09	.13	.17	.22	.27	.39	.53	.69	.88	1.04	2.43	4.32	6.88	9.72	13.25			
6″					.01	.01	.01	.02	.03	.05	.06	.08	.10	.15	.20	.27	.34	.40	.95	1.69	2.64	3.79	5.27	6.78	8.54	10.55
7″								.01	.01	.02	.03	.04	.05	.06	.09	.12	.15	.18	.43	.77	1.19	1.73	2.35	3.07	3.89	4.79
8″										.01	.01	.01	.02	.03	.04	.06	.08	.09	.22	.39	.60	.87	1.19	1.55	1.97	2.46
9″													.01	.02	.02	.03	.04	.05	.12	.21	.33	.48	.65	.85	1.08	1.33
10″														.01	.01	.02	.02	.03	.06	.12	.19	.28	.37	.49	.66	.77
12″																.01	.01	.01	.02	.04	.07	.11	.15	.19	.25	.30
14″																			.01	.02	.03	.05	.06	.09	.11	.14
16″																				.01	.01	.02	.03	.04	.05	.07

For longer or shorter pipes the friction loss is proportional to the length, *i.e.*, for 500 feet ½ of the above; for 4,000 feet four times the above, etc.

COMPRESSED AIR TRANSMISSION

LOSS OF PRESSURE IN POUNDS BY FRICTION IN 1000 FEET LENGTHS OF PIPE

Size Pipe	*XIV* DELIVERY IN CUBIC FEET OF COMPRESSED AIR PER MINUTE AT 100 LBS. GAGE																									
	6.41	9.61	12.81	15.81	19.22	22.39	25.62	31.62	38.44	44.78	51.24	57.65	63.24	76.88	89.56	102.5	115.3	126.5	192.2	256.2	316.2	384.4	447.8	512.4	576.5	632.4
	EQUIVALENT DELIVERY IN CUBIC FEET OF FREE AIR PER MINUTE																									
	50	75	100	125	150	175	200	250	300	350	400	450	500	600	700	800	900	1000	1500	2000	2500	3000	3500	4000	4500	5000
1"	11.89	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1¼"	3.29	7.42	13.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1½"	1.28	2.87	5.11	7.75	11.42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2"	.27	.62	1.15	1.68	2.48	3.36	4.43	6.72	9.95	13.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2½"	.08	.19	.34	.52	.76	1.03	1.36	2.06	3.04	4.11	5.40	6.85	8.21	12.21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3"	.03	.07	.12	.19	.29	.39	.51	.77	1.14	1.54	2.06	2.57	3.08	4.58	6.19	8.13	10.23	12.39	.....	.....	.....	.....	.....	.....	.....	.....
3½"	.01	.03	.05	.08	.13	.17	.23	.35	.51	.69	.92	1.16	1.39	2.14	2.79	3.67	4.64	5.60	12.81	.....	.....	.....	.....	.....	.....	.....
4"	.....	.01	02	04	.06	.09	.12	.17	.25	.34	.45	.57	.68	1.03	1.38	1.81	2.29	2.76	6.68	11.35	.....	.....	.....	.....	.....	.....
4½"	.....	.....	.01	.02	.03	.04	.06	.09	.14	.19	.25	.32	.38	.57	.77	1.00	1.27	1.23	3.51	6.61	9.56	14.04	.....	.....	.....	.....
5"	.....	.....	.....	.01	.02	.03	.04	.05	.08	.11	.15	.18	.22	.33	.44	.57	.76	.88	2.03	3.62	5.51	8.11	10.95	14.48	.....	.....
6"	.....	.....	.....	.....	.01	.01	.02	.02	.03	.04	.05	.07	.08	.12	.17	.22	.28	.34	.78	1.41	2.14	3.16	4.26	5.59	7.04	8.51
7"	.....	.....	.....	.....	.....	.....	.01	.01	.01	.02	.03	.03	.04	.05	.07	.10	.13	.16	.36	.67	.97	1.44	1.93	2.55	3.22	3.88
8"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.02	.02	.03	.04	.05	.06	.08	.18	.33	.49	.76	.98	1.30	1.84	1.98
9"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.02	.02	.03	.04	.04	.09	.18	.27	.39	.53	.72	.89	1.07
10"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.02	.02	.03	.05	.10	.16	.23	.31	.41	.52	.63
12"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.01	.02	.04	.06	.09	.12	.16	.21	.25
14"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.02	.03	.04	.05	.07	.09	.11
16"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.02	.03	.04	.05	.06

Size Pipe	*XV* DELIVERY IN CUBIC FEET OF COMPRESSED AIR PER MINUTE AT 125 LBS. GAGE																									
	5.26	7.89	10.51	13.15	15.79	18.41	21.05	26.30	31.58	36.81	42.10	47.30	52.60	63.20	73.70	84.20	94.70	105.1	157.9	210.5	263.0	315.8	368.1	422.0	473.0	526.0
	EQUIVALENT DELIVERY IN CUBIC FEET OF FREE AIR PER MINUTE																									
	50	75	100	125	150	175	200	250	300	350	400	450	500	600	700	800	900	1000	1500	2000	2500	3000	3500	4000	4500	5000
1"	9.88	22.20	39.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1¼"	2.70	6.07	10.82	16.88	24.33	33.05	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1½"	1.05	2.37	4.22	6.58	9.47	12.90	16.84	26.30	37.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2"	.23	.51	.91	1.42	2.04	2.78	3.63	5.68	8.18	11.08	14.51	18.38	22.68	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2½"	.07	.16	.28	.43	.63	.85	1.11	1.73	2.51	3.39	4.44	5.61	6.95	10.00	13.60	17.80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3"	.03	.06	.10	.16	.23	.32	.42	.65	.94	1.27	1.67	2.11	2.61	3.76	5.11	6.68	8.45	10.42	23.48	.....	.....	.....	.....	.....	.....	.....
3½"	.01	.03	05	.07	.11	.14	.19	.29	.42	.58	.75	.95	1.18	1.69	2.31	3.01	3.81	4.71	10.59	18.81	29.40	.....	.....	.....	.....	.....
4"	.....	.01	.02	.04	.05	.07	.09	.15	.21	.28	.37	.47	.58	.84	1.14	1.49	1.88	2.32	5.23	9.30	14.52	20.90	28.51	.....	.....	.....
4½"	.....	.....	.01	.02	.03	.04	.05	.08	.12	.16	.21	.26	.32	.46	.63	.83	1.04	1.29	2.90	5.15	8.05	11.59	15.78	20.61	26.10	32.20
5"	.....	.....	.....	.01	.02	.02	.03	.05	.07	.09	.12	.15	.18	.27	.36	.47	.60	.74	1.65	2.94	4.60	6.63	9.01	11.80	14.90	18.45
6"	.....	.....	.....	.....	.01	.01	.01	.02	.03	.04	.05	.06	.07	.10	.14	.18	.23	.29	.64	1.15	1.80	2.59	3.53	4.61	5.83	7.20
7"	.....	.....	.....	.....	.....	.....	.....	.01	.01	.02	.02	03	03	.05	.06	.08	.11	.13	.29	.52	.82	1.18	1.61	2 19	2.65	3.27
8"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	01	.02	.02	.03	04	.05	.07	.15	.26	.41	.60	.81	1.06	1.34	1.65
9"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.01	.02	.02	.03	.04	.08	.15	.23	.33	.45	.58	.73	.90
10"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.01	.02	.02	.05	.08	.13	.19	.26	.34	.43	.53
12"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.01	.02	.03	.05	.07	.10	.13	.17	.21
14"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.02	.02	.03	.04	.06	.08	.10
16"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.02	.02	.03	.04	.05

For longer or shorter pipes the friction loss is proportional to the length, *i.e.*, for 500 feet ½ of the above; for 4,000 feet four times the above, etc.

XVI. DISCHARGE OF AIR THROUGH AN ORIFICE IN CUBIC FEET OF FREE AIR PER MINUTE

FLOWING FROM A ROUND HOLE IN RECEIVER INTO THE ATMOSPHERE

Diameter of Orifice, Inches	RECEIVER GAGE PRESSURE															
	2 Pounds	5 Pounds	10 Pounds	15 Pounds	20 Pounds	25 Pounds	30 Pounds	35 Pounds	40 Pounds	45 Pounds	50 Pounds	60 Pounds	70 Pounds	80 Pounds	90 Pounds	100 Pounds	125 Pounds
1/64	.038	.0597	.0842	.103	.119	.133	.156	.173	.19	.208	.225	.26	.295	.33	.364	.40	.486
1/32	.153	.242	.342	.418	.485	.54	.632	.71	.77	.843	.914	1.05	1.19	1.33	1.47	1.61	1.97
1/16	.647	.965	1.36	1.67	1.93	2.16	2.52	2.80	3.07	3.36	3.64	4.2	4.76	5.32	5.87	6.45	7.85
1/8	2.435	3.86	5.45	6.65	7 7	8.6	10.	11.2	12.27	13.4	14.50	10.8	19.	21.2	23.50	25.8	31.4
1/4	9.74	15.40	21.8	26.70	30.8	34.5	40.	44.7	49.09	53.8	58.2	67.	76.	85.	94.	103.	125.
3/8	21.95	34.60	49.	60.	69.	77	90.	100.	110.45	121.	130.	151.	171.	191.	211.	231.	282.
1/2	39.	61.60	87.	107	123.	138.	161.	179.	196.35	215.	232.	268.	304.	340.	376.	412.	502.
5/8	61.	96.50	136.	167.	193.	216.	252.	280.	306.80	336.	364.	420.	476.	532.	587.	645.	785.
3/4	87.60	133.	196.	240.	277.	310.	362.	400.	441.79	482.	522.	604.	685.	765.	843.	925.	
7/8	119.50	189.	267.	326.	378.	422.	493.	550.	601.32	658.	710.	622.	930.	1004.			
1	156.	247.	350.	427.	494.	550.	645.	715.	785.40	860.	930.						
1 1/4	242.	384.	543.	665.	770.	860.	1000.										
1 1/2	350.	550.	780.	960.													
2	625.	985.															

DRILL CAPACITY TABLES

THE tables on the next page will determine the amount of free air required to operate rock drills at various altitudes with air at given pressures.

The tables have been compiled from a review of a wide experience and from tests run on drills of various sizes. They are intended for fair conditions in ordinary hard rock, but owing to varying conditions it is impossible to make any guarantee without a full knowledge of existing conditions.

In soft material, where the actual time of drilling is short, more drills can be run with a given sized compressor than when working in hard material, when the drills would be working continuously for a longer period, thereby increasing the chance of all the drills operating at the same time.

In tunnel work, where the rock is hard, it has been the experience that more rapid progress has been made when the drills were operated under a high air pressure, and it has been found profitable to provide compressor capacity in excess of the requirements by about 25 per cent. There is also a distinct advantage in having a compressor of large capacity, in that it saves the trouble and expense of moving the compressor as the work progresses, and will not interfere with the work of driving the tunnel.

No allowance has been made in the tables for loss due to leaky pipes, or for transmission loss due to friction; but the capacities given are merely the displacement required, so that when selecting a compressor for the work required these matters must be taken into account.

Table XVII gives cubic feet of free air required to operate one drill of a given size and under a given pressure.

Table XVIII gives multiplication factors for altitudes and number of drills, by which the air consumption of one drill must be multiplied in order to give the total amount of air.

XVII. CUBIC FEET OF FREE AIR REQUIRED TO RUN ONE DRILL OF SIZE AND AT THE PRESSURE STATED BELOW

Gage Pressure	CYLINDER DIAMETER OF DRILL												
	2"	2¼"	2½"	2¾"	3"	3⅛"	3 3/16"	3¼"	3½"	3⅝"	4¼"	5"	5½"
60	50	60	68	82	90	95	97	100	108	113	130	150	164
70	56	68	77	93	102	108	110	113	124	129	147	170	181
80	63	76	86	104	114	120	123	127	131	143	164	190	207
90	70	84	95	115	126	133	136	141	152	159	182	210	230
100	77	92	104	126	138	146	149	154	166	174	199	240	252

XVIII. MULTIPLIERS TO DETERMINE CAPACITY OF COMPRESSOR REQUIRED TO OPERATE FROM 1 TO 70 ROCK DRILLS AT ALTITUDES COMPARED WITH SEA LEVEL

Altitude Above Sea Level	NUMBER OF DRILLS																	
	1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	40	50	60	70
	MULTIPLIERS																		
0	1.	1.8	2 7	3.1	4 1	4.8	5.4	6.0	6.5	7.1	8.1	9.5	11.7	13.7	15.8	21.4	25.5	29 4	33.2
1000	1.03	1.85	2 78	3 5	4.22	4.94	5.56	6.18	6.69	7.3	8.34	9.78	12.05	14.1	16.3	22.0	26.26	30.3	34.2
2000	1.07	1.92	2.89	3 64	4.39	5.14	5.78	6.42	6.95	7.60	8.67	10.17	12.52	14.66	16.9	22.9	27.28	31 46	35.52
3000	1.10	1.98	2 97	3.74	4.51	5.28	5.94	6.6	7.15	7.81	8.91	10.45	12.87	15.07	17.38	23.54	28.05	32.34	36.52
4000	1.14	2 05	3.08	3.88	4.67	5.47	6.15	6.84	7.41	8.09	9.23	10.83	13 34	15.62	18.01	24.4	29.07	33.52	37.8
5000	1.17	2.10	3.16	3.98	4.8	5.62	6.32	7.02	7.61	8.31	9.48	11.12	13.69	16.03	18.49	25.04	29.84	34 4	38.84
6000	1.20	2.16	3.24	4.08	4.9	5.76	6.48	7.2	7.8	8.52	9.72	11.4	14.04	16.44	18.96	25.68	30.6	35 4	39.84
7000	1.23	2.21	3.32	4.18	5.04	5.9	6.64	7.38	7.99	8 73	9 96	11.68	14.39	16.85	19.43	26.32	31.36	36 16	40.84
8000	1.26	2.27	3.40	4.28	5.17	6.05	6.8	7.56	8.19	8.95	10.21	11.97	14.74	17.26	19.9	26.96	32 13	37.04	41.83
9000	1.29	2.32	3 48	4.39	5.29	6.19	6.96	7 74	8.38	9.16	10.45	12.26	15.09	17.67	20.38	27.6	32.9	37.92	42 83
10000	1.32	2.38	3.56	4.49	5.41	6.34	7.13	7.92	8.58	9.37	10.69	12.54	15.44	18.08	20.86	28.25	33.66	38.8	43.82
12000	1.37	2.47	3.70	4.66	5.62	6.57	7.4	8.22	8.9	9.73	11.1	13.02	16.03	18.77	21.64	29.32	34.94	40 28	45.48
15000	1.43	2.57	3.86	4.86	5.86	6.86	7.72	8.58	9.3	10.15	11.58	13.58	16.73	19.59	22.59	30.6	36.46	42 04	47.47

EXAMPLE. — Required the amount of free air necessary to operate thirty 5-inch drills at 9,000 feet altitude, using to operate these drills air at a gage pressure of 80 pounds per square inch.

From Table XVII we find, when operating the drills at 80 pounds gage pressure at sea level, that one 5-inch drill requires 190 cubic feet of free air per minute.

From Table XVIII we also find that the factor for 30 drills at 9,000 feet altitude is 20.38; multiplying 190 cubic feet by 20.38 gives 3,872 cubic feet free air per minute, which is the displacement of a compressor for the above outfit under average conditions, to which must be added pipe line losses, such as friction and leakage.

XIX. COMPRESSED AIR TABLE FOR PUMPING PLANTS

For the convenience of engineers and others figuring on pumping plants to be operated by compressed air, we subjoin a table by which the pressure and volume of air required for any size pump can be readily ascertained. Reasonable allowances have been made for loss due to clearances in pump and friction in pipe.

Ratio of Diameters	PERPENDICULAR HEIGHT, IN FEET, TO WHICH THE WATER IS TO BE PUMPED															
	25	50	75	100	125	150	175	200	225	250	300	350	400	450	500	
1 to 1	13.75	27.5	41.25	55.0	68.25	82.5	96.25	110.0	.…	.…	.…	.…	.…	.…	.…	Air pressure at pump
	0.21	0.45	0.60	0.75	0.89	1.04	1.20	1.34	.…	.…	.…	.…	.…	.…	.…	Cubic feet of free air per gallon of water
1½ to 1	.…	12.22	18.33	24.44	30.33	36.66	42.76	48.88	55.0	61.11	73.32	85.4	97.66	.…	.…	Air pressure at pump
	.…	0.65	0.80	0.95	1.09	1.24	1.39	1.53	1.68	1.83	2.12	2.41	2.70	.…	.…	Cubic feet of free air per gallon of water
1¾ to 1	.…	.…	13.75	19.8	22.8	27.5	32.1	36.66	41.25	45.83	55.0	64.16	73.33	82.5	.…	Air pressure at pump
			0.94	1.14	1.24	1.30	1.54	1.69	1.84	1.99	2.39	2.59	2.88	3.19	.…	Cubic feet of free air per gallon of water
2 to 1		.…	.…	13.75	17.19	20.63	24.06	27.5	30.94	34.38	41.25	48.13	55.0	61.88	68.75	Air pressure at pump
		.…	.…	1.23	1.37	1.52	1.66	1.81	1.96	2.11	2.40	2.69	2.98	3.28	3.57	Cubic feet of free air per gallon of water
2¼ to 1	.…	.…	.…	.…	13.75	16.5	19.25	22.0	24.75	27.5	33.0	38.5	44.0	49.5	55.0	Air pressure at pump
				.…	1.533	1.68	1.83	1.97	2.12	2.26	2.56	2.85	3.15	3.44	3.73	Cubic feet of free air per gallon of water
2½ to 1					.…	13.2	15.4	17.6	19.8	22.0	26.4	30.8	35.2	39.6	44.0	Air pressure at pump
		.…			.…	1.79	1.98	2.06	2.104	2.34	2.62	2.88	3.18	3.36	3.23	Cubic feet of free air per gallon of water

To find the amount of air and pressure required to pump a given quantity of water a given height find the ratio of diameters between water and air cylinders, and multiply the number of gallons of water by the figure found in the column for the required lift. The result is the number of cubic feet of free air. The pressure required on the pump will be found directly above in the same column. For example: The ratio between cylinders being 2 to 1, required to pump 100 gallons, height of lift 250 feet. We find under 250 at ratio 2 to 1, the figures 2.11; 2.11 × 100 = 211 cubic feet of free air. The pressure required is 34.38 pounds delivered at the pump piston.

XX. COMPRESSED AIR TABLE FOR HOISTING ENGINES

The following table is intended to give an approximate idea of the volume of free air required for operating hoisting engines, the air being delivered to the engines at 60 pounds gage pressure. There are so many variable conditions in the operation of hoisting by the hoisting engines in common use that accurate computations can only be offered when fixed data are given. In the table, the hoisting engine is assumed to actually run but one-half of the time for hoisting, while the compressor, of course, runs continuously. If the engine runs less than one-half the time, as it usually does, the volume of air required will be proportionately less, and *vice versa*. The table is computed for maximum loads, which also in practice may vary widely. From the intermittent character of the work of a hoisting engine the parts are able to resume their normal temperature between the hoists, and there is little probability of the annoyance of freezing up the exhaust passages.

TABLE OF THE VOLUME OF FREE AIR REQUIRED FOR OPERATING HOISTING ENGINES

THE AIR COMPRESSED TO 60 POUNDS GAGE PRESSURE

Diameter of Cylinder Inches	Stroke Inches	Revolutions per Minute	Normal Horse power	Actual Horse power	Weight Lifted Single Rope	Cubic Feet of Free Air Required
Single Cylinder Hoisting Engine						
5	6	200	3	5.9	600	75
5	8	160	4	6.3	1000	80
6¼	8	160	6	9.9	1500	125
7	10	125	10	12.1	2000	151
8¼	10	125	15	16.8	3000	170
8½	12	110	20	18.9	5000	238
10	12	110	25	26.2	6000	330
Double Cylinder Hoisting Engine						
5	6	200	6	11.8	1000	150
5	8	160	8	12.6	1650	160
6¼	8	160	12	19.8	2500	250
7	10	125	20	24.2	3500	302
8¼	10	125	30	33.6	6000	340
8½	12	110	40	37.8	8000	476
10	12	110	50	52.4	10000	660
12¼	15	100	75	89.2	....	1125
14	18	90	100	125.	....	1587

XXI. AIR REQUIRED

TO HOIST ONE TON (2240 POUNDS) OF ROCK AT VARIOUS ANGLES OF SLOPE

ANGLES MEASURED FROM THE HORIZONTAL

Original By F. A. Halsey

Angle of slope, degrees......	0	5	10	15	20	25	30	35	40	45	50	60	75	90
Cubic feet of free air consumed per minute of actual hoisting, speed of rope being 350 feet per minute..............	11	90	160	230	320	400	470	520	590	650	700	790	880	900
Cubic feet of free air consumed for each 100 feet of hoist measured on the slope................	3.14	25.7	45.6	65.7	91.2	114	134	148	168	186	200	225	250	257

This table includes the power required to hoist the skip and rope and overcome the friction. It assumes that 20 per cent of the power of the engine is consumed in its own friction and that of the gearing; that the skip weighs one-half as much as its contents; and that the traction on a horizontal mine track is 30 pounds per ton; and it provides for 500 feet of wire rope.

The consumption of air is based on the assumption that the engine is of the plain slide valve pattern, of good construction and in good condition, and that it is loaded to nearly or quite full capacity. It should be remembered that the table gives the consumption of air while the engine is actually in motion. In estimating the consumption per hour, allowance should be made for the time that the engine stands idle If the compressor is a large one, doing other work — drilling, pumping, etc. — the compressor capacity should be based on the hourly consumption in which allowance is made for the time the hoist stands idle, but if the compressor is driving the hoist alone, it is advisable to consider the hoist as running continuously (whether it really is or not) and figure the compressor on that basis. For a balanced hoist use only the *unbalanced load* in applying this rule. If the engine is not loaded to its full capacity, the air being throttled, it will require more air to do the same work. Decreasing the speed of hoisting will diminish the power developed and the air consumed per minute, but as the time of hoisting is thereby lengthened, the air consumed per hoist will remain unchanged. Increased speed will give a corresponding result.

Index

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GRIFFITH-STILLINGS PRESS
368 CONGRESS ST., BOSTON

CLASS "NF-1"

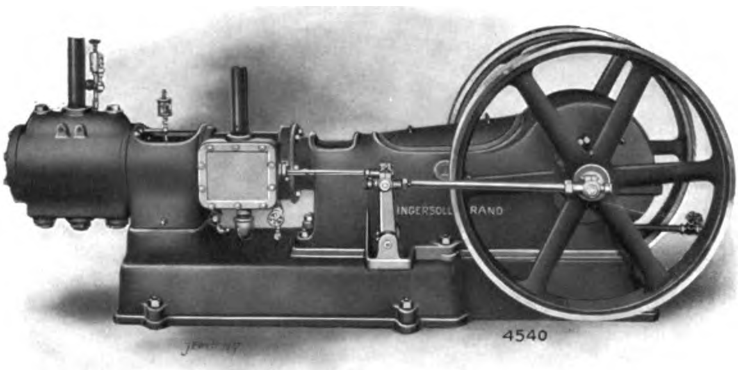
STEAM DRIVEN SINGLE STAGE STRAIGHT LINE

AIR COMPRESSORS

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

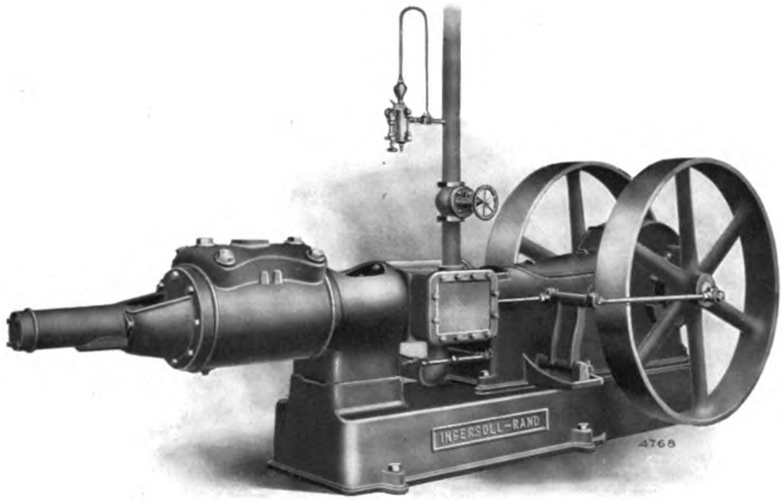
Form No. 3009. March, 1910



Class "NF-1" Compressor with "Direct Lift" Inlet and Discharge Valves; Standard Construction on Sizes up to and including 10 and 12 x 10 inches

THE idea behind the new Class "NF-1" steam driven single stage straight line compressor, just brought out by the Ingersoll-Rand Company, was to produce a small machine fully conforming with the Company's most up-to-date practice in larger compressors; a machine meeting the exacting demands of present-day service in which high-duty performance is required even in the small accessories of the main power or industrial plant. The ready acceptance of this new type at the hands of the trade, within two or three months of its introduction, confirms the confidence of the Company that the buying public demands and is seeking a strictly high-grade compressor, even for the minor duties for which compressed air is used.

The "small compressor problem" has been a difficult one; and it has remained for the Ingersoll-Rand Company, builders of more than a million horse-power in air compressors, to produce, in its Class "NE-1" power driven, and its Class "NF-1"



Standard Class "NF-1" Compressor with "Hurricane-Inlet" and "Direct Lift" Discharge Valves, used on the Larger Sizes—12¼-inch Air Cylinder and Larger

steam driven, compressors the most advanced types to date in the straight line design for small capacities.

The Class "NE–1" small compressor—the power-driven prototype of the Class "NF–1" here described—is covered by Pamphlet No. 3110; and it has received as quick recognition as the present "NF–1." The air ends of the two types are, in fact, identical; and their capacity, speed and pressure ratings are the same throughout the two series.

Some Elements of Quality

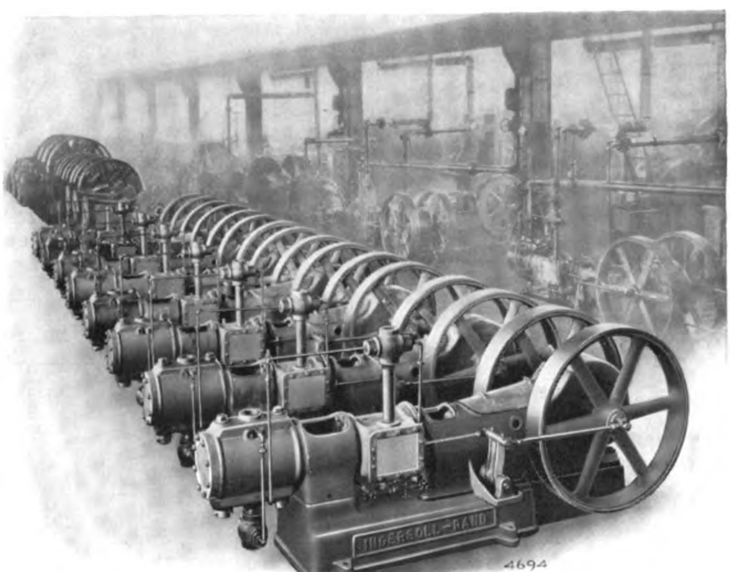
There are certain qualities fundamentally requisite in the commercially successful small compressor. Special care must be exercised in the selection of the very best materials, so that the requisite strength may be had without undue size and weight. Where possible, the natural quality of such materials as steel must be improved by special treatment. The best of workmanship must be applied, so that adjustments correctly made at the outset may be maintained. The design of each part and of the machine as a whole must be such that every possible advantage may be had from the proper relation of the parts; in other words, the compressor must be a consistent unit. Every reasonable precaution must be taken to reduce the losses in the steam end, by proper valve movements; and in the air end, by adequate cooling.

The small compressor, moreover, is usually only a minor accessory of a large machine equipment, so that it probably receives less careful attention than a larger unit. It is of the utmost importance, therefore, that it shall be as completely automatic as possible, and capable of "taking care of itself" without rapid deterioration and loss of efficiency.

These qualities, so vitally essential, are not to be cheaply secured; and the problem of producing a compressor which embodies them, at a price which is commercially attractive, is one requiring the best engineering and the widest experience. The Class "NF–1" Compressor has proved itself to be the best solution of this problem, in so far as the steam driven straight line type is concerned.

The General Type

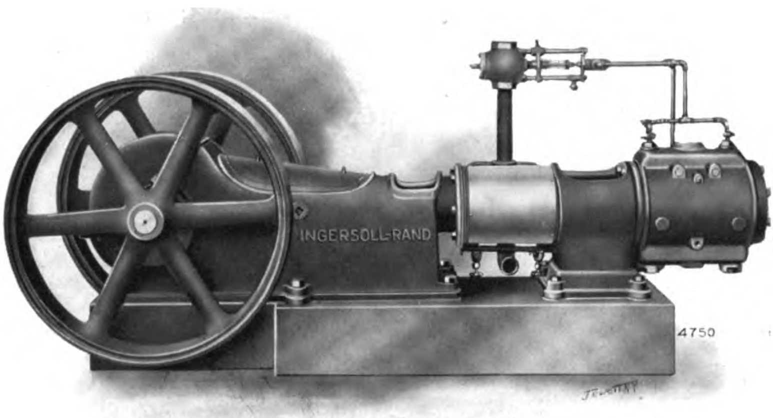
The Class "NF-1" Compressor is a twin-fly-wheel, center-crank, enclosed type, with steam and air cylinders arranged in tandem. The feature of special note, and clearly brought out in the illustrations of this machine, is the massive construction —plain and simple in outline but embodying every element of strength.



A Group of Class "NF-1" Compressors Complete and Ready for Stock, with Machines Under Test in the Background

The simplicity of this machine is worthy of special note; for it is doubtful if any other type of compressor embodies so many of the fundamentals of economy and endurance, with such a small number of parts.

An examination of the sectional illustrations in these pages will reveal the care bestowed upon sustained good economy and continued satisfactory performance. Not a detail has been

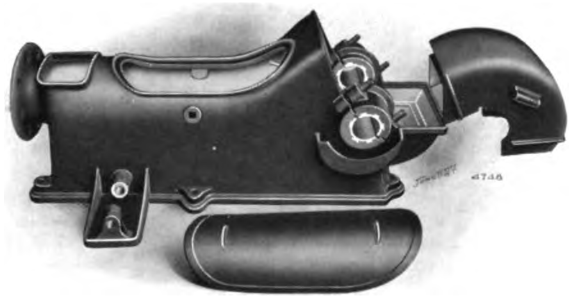


The Sub-Base of the "NF-1 Compressor may be Omitted on Order, and the Machine Mounted Direct on the Foundation, as here Shown

slighted. Materials are disposed with special attention to rigidity without excess weight. Bearings are of unusually generous proportions and are carefully finished to reduce friction losses. The crosshead is of cast steel and the cranks are counterbalanced to ensure steadiness of operation at high speeds. Fly-wheels are of ample weight. The very important features of ready accessibility have been provided for at every point; and a special effort has been made to permit easy adjustment of all parts which may require attention. The importance of cleanliness has also been considered and provision made to guard against the escape of oil.

The Main Frame and Sub-Base

The standard "NF-1" construction includes a cast sub-base extending under the main frame and the distance piece between the cylinders. On special order, however, the machine will be furnished without the sub-base, in which case a pedestal



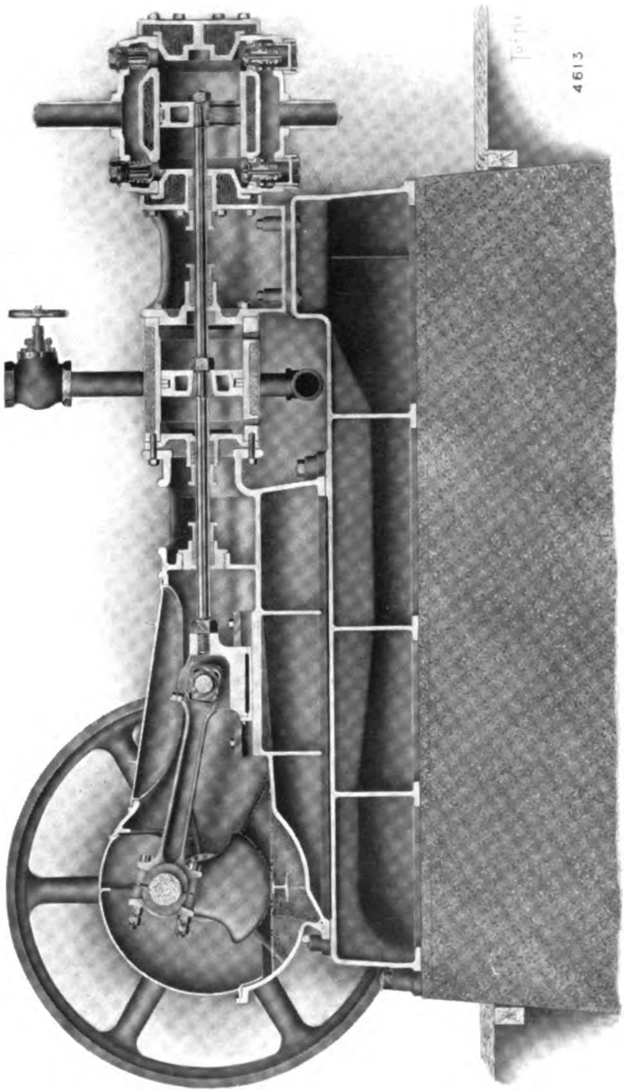
Main Frame and Oil Covers of Class "NF-1" Compressor

or foot-piece is provided beneath the distance piece, both main frame and pedestal being bolted directly to the foundation.

The sub-base is strongly ribbed and provided with wide flanges bearing on the foundation. Planed surfaces on its top receive the main frame and distance piece. Strong bolts or studs hold all together.

The Sub-Base Used on Standard "NF-1" Compressors

The main frame is broad and deep, and provided with ample bearing on either the sub-base or foundation, as the case may be. The sides are carried up almost to the top of the cylinder, and carried over as a hood between the main bearings, adding stiffness and strength to these parts. The bearings are of ample dimensions, and well braced and supported. Bearing caps have suitable adjustment for wear. The crosshead guides are flat. The opening in the top of the frame is closed by a light cast-iron plate; and a cast-iron cover is placed over the crank end of the frame. This construction provides the closed chamber for the splash lubrication system. Oil lips beneath the shaft bearings catch



Longitudinal Section of "Direct Lift" Inlet and Discharge Valve Type of Class "NF-1" Compressor

escaping oil and return it to the crank basin. Oil collars on wheel hubs prevent escape of oil out upon the wheels. A plate with an auxiliary stuffing box closes the frame near the steam end and prevents condensed steam from the piston rod mingling with the oil. Main bearings are babbitted.

The Steam Cylinder

The steam cylinder is covered on the barrel with non-conducting material and lagged with a planished steel cover. The steam valves are of plain slide or "D" type, with cut-off adjusted for average operating conditions. The valve gear is driven from a pin in the end of crank shaft, this allowing the heavy fly-wheel to be placed close to the main bearing and avoiding the use of the usual large diameter eccentric. A single rocker supported on an extension of the main frame guides the valve stem. Cylinder drain cocks are provided.

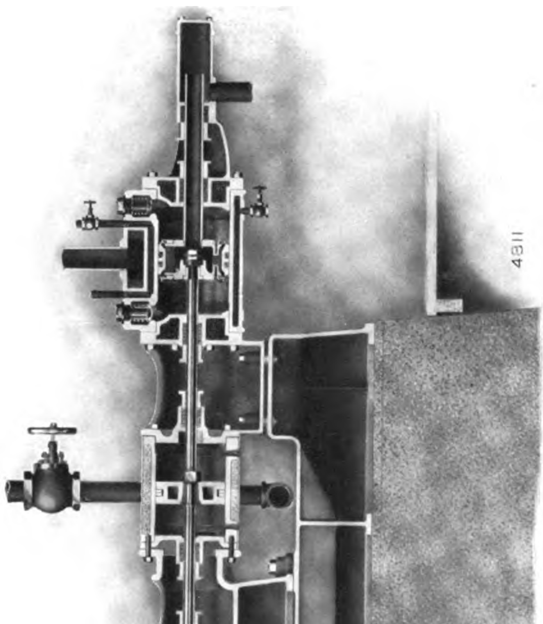
The Distance Piece

Between the steam and air cylinders is a distance piece, constituting also the back steam cylinder head and the front air head. This is a closed casting, in the bottom of which oil and water from the piston rod collect and can be withdrawn through a drain plug in the side.

The Air Cylinder

The air cylinder is completely water-jacketed on heads and barrel. Air inlet valves on machines of air cylinder diameter expressed in even inches are of vertical "Direct Lift" type, set in the bottom of the cylinder. On machines with fractional air cylinder diameters the "Hurricane-Inlet" valve is standard. All sizes have "Cushioned Direct Lift" discharge valves, set vertically in the top of the cylinder barrel. "Direct Lift" inlet valve machines have a closed pipe inlet; and "Hurricane-Inlet" types can be furnished, on order, with a closed Atmospheric Intake, at extra cost, except where the "A-35" Unloader is used, when no intake is necessary.

Clearance spaces have been reduced to the practical limit. The air piston is of generous length, carefully fitted to the cylinder and equipped with expansion piston rings. Every detail of the air end has been worked out to assure the maximum delivery of compressed air. The volumetric efficiency of Class "NF-1" Compressors is unusually high for small machines.



Longitudinal Section of Standard Class "NF-1" Compressor with "Hurricane-Inlet" and "Direct Lift" Discharge Valves

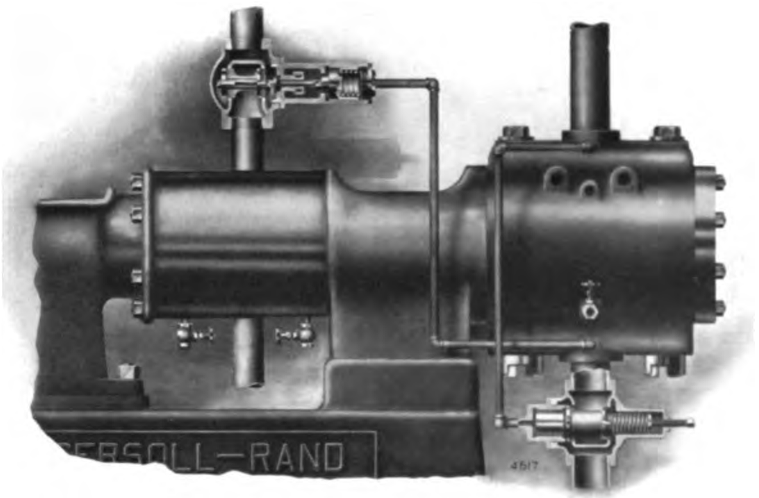
The Lubrication System

Steam and air cylinders have high-grade sight-feed lubricators. A special waste-packed gland is provided for the piston rod between the cylinders and for the inlet pipe. This with an occasional oiling provides a constant source of lubrication for piston rod and inlet pipes. The pin driving the valve gear is provided with a grease cup.

All other bearings are oiled by the "splash" system from the main frame. The frame, with its covers, forms a closed chamber, with a quantity of oil in the basin beneath the cranks, into which cranks and connecting rod dip at each revolution. This splashes the oil to every bearing in the front of the machine—main bearings, crank and crosshead pins, crosshead guides, and steam piston rods. These parts are literally flooded with oil at all times, reducing friction and wear to almost a negligible quantity, and absolutely preventing any cutting or heating. The oil is prevented from escaping by the closely fitting covers, making the machine cleanly and economical of lubricant. A drain for the oil basin is provided.

Accessibility

The air cylinder is accessible on every side and easily removed when necessary because the stud nuts holding it to the distance piece are reached without disturbing any other part. The air piston is accessible by removing the back air head, and the steam piston by removing distance piece and air cylinder together. All piston rod stuffing boxes are easily reached through large openings in the top of frame and distance piece. Air discharge valves, and air inlet valves on "Direct Lift" inlet types, can be unscrewed and removed in a moment. The "Hurricane-Inlet" valves are reached by removing the back air head. The covers in the frame enclosing cranks, connecting rod and crosshead, are not screwed or bolted in place, but are retained by rims and their own weight, so that they can be simply lifted off. The crosshead pin can be taken out through openings in the frame closed by screw plugs. The steam chest cover is on the side of the machine and the valve gear perfectly accessible. No compressor offers more complete and ready accessibility than the "NF-1."



"A-35" Air Unloader and "A-36" Steam Regulator, Standard on "NF-1" Compressors

Regulation

No regulator is furnished as a part of the standard equipment of Class "NF-1" compressors, but it will be furnished on order, at extra cost.

The method of regulation usually to be preferred is a combination of the "A-35" Unloader on the air intake, with the "A-36" Steam Regulator on the steam supply. These two devices, while similar in construction, differ in their operation. They consist of a double-disk valve normally held open by a spring. When receiver pressure exceeds normal, it acts on the air unloader valve to close it against the spring pressure. This produces a vacuum in the intake, which is communicated to the steam regulator. Normally, the spring tension in the latter holds the steam valve open. But when the vacuum from the air intake reduces the air pressure on the spring end of the steam regulator piston, atmospheric pressure on the opposite side closes this valve, shutting off steam and reducing speed. This cycle of operations occupies but a very short time and the regulation is close and economical. A by-pass valve is provided in the side of the steam regulator by means of which enough steam is passed at all times to prevent the compressor from stopping. Various receiver pressures may be provided for by varying the spring tension in the controlling mechanism, by

means of the screw provided. Recovery of normal receiver pressure automatically restores full running conditions.

Other regulators, optional on order at extra cost, are: The "A–28" Air Unloader with "A–14" Steam Regulator, the Variable Speed Governor, and the "Air Ball" Speed and Pressure Regulator.

Sizes and Capacities

Class "NF–1" Compressors are built in four standard strokes—6, 8, 10 and 12 inches—with cylinder diameters, capacities and dimensions as given in the table on the this page. On page 12 a dimension chart is given, showing other data not given in the table below.

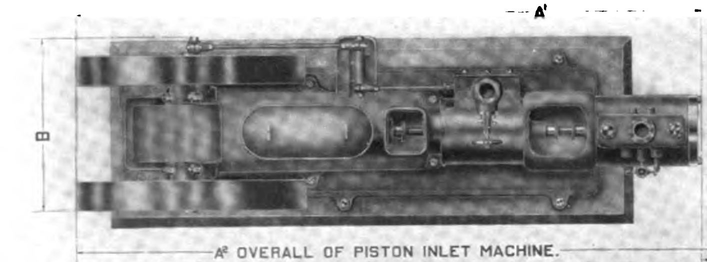
Equipment

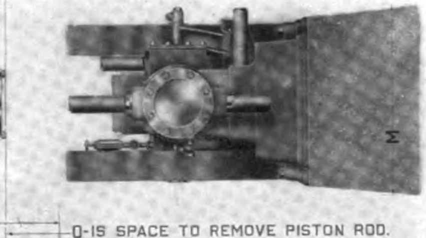
The standard equipment includes the full complement of lubricating devices, all piping which may be considered as a part of the machine, a throttle-valve, the necessary special machine wrenches, and foundation plans. As stated, a regulator is special and extra. Foundation bolts, nuts and washers also are furnished only on order, at extra cost.

STRAIGHT LINE STEAM DRIVEN AIR COMPRESSORS, Class "NF-1."

SPLASH LUBRICATION. STEAM PRESSURE 80 TO 120 LBS.

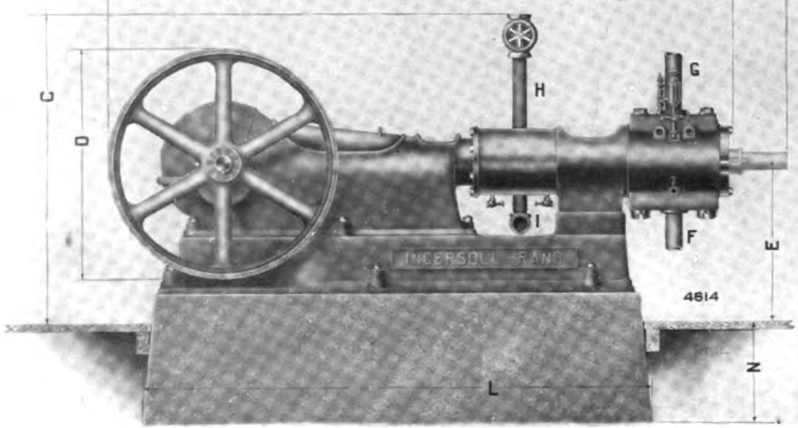
Telegraph Name	Size of Cylinders Inches			Revolutions per Minute	Piston Speed in Feet per Minute	Piston Displacement Cubic Feet per Minute	Air Pressure Designed For	I. H. P. in Steam Cylinder	Diameter of Fly-Wheels Feet and Inches	Over-All Dimensions, Feet and Inches		
	Diameter of Steam Cylinder	Diameter of Air Cylinder	Stroke							Length	Width	Height from Floor
Famat	6	6	6	220	220	42	45–100	5½– 8½	2-4	6– 0	2-0	4– 7
Famev	6	8	6	220	220	76	20– 45	6 –10½	2-4	6– 1	2-0	4– 7
Famox	6	10	6	210	210	114	15– 20	8 –10	2-4	6– 2	2-0	4– 7
Famuy	8	8	8	210	280	96	50–100	12½–19	3-3	8–10	2-5	4–10
Fanav	8	10	8	200	266	144	30– 50	14½–20	3-3	8–11	2-5	4–10
Fanew	8	12	8	200	266	207	20– 30	16 –22	3-3	9– 0	2-5	4–10
Fanix	10	10	10	200	333	179	55–100	25 –36	4-0	10– 8	3-0	5– 4
Fanoy	10	12	10	200	333	258	35– 55	28 –38	4-0	10– 8	3-0	5– 4
Fanuz	10	14¼	10	190	317	335	25– 35	30 –38	4-0	12– 5	3-0	5– 4
Faobt	10	16¼	10	180	300	414	15– 25	27 –39	4-0	12– 5	3-0	5– 4
Fapaw	12	12¼	12	200	400	310	60–100	46 –62	5-0	15– 0	3-9	6– 0
Fapex	12	14¼	12	190	380	400	40– 60	47 –62	5-0	15– 2	3-9	6– 0
Fapoz	12	16¼	12	180	360	495	30– 40	50 –61	5-0	15– 4	3-9	6– 0
Fapub	12	18¼	12	180	360	627	15– 30	38 –64	5-0	15– 6	3-9	6– 0





FOUNDATION.			
STROKE	L	M	N
6"	6'-0"	2'-3"	19"
8"	8'-1"	2'-6"	2'-3"
10"	9'-4"	3'-0"	3'-0"
12"	9'-9"	3'-4"	"

PISTON ROD
O
12"
15"
18"
20"



SIZE	A¹	A²	B	C	O	E	F	G	H	I
6-6-6	6'-0"		2'-0"	4'-7"	2'-4"	2'-3"	2"	2"	1 1/2"	1 1/2
6-8-6	6'-1"		"	"	"	"	2 1/8"	2 1/2"	"	"
6-10-6	6'-2"		"	"	"	"	"	"	"	"
8-8-8	8'-10"		2'-5"	4'-10"	3'-3"	2'-3"	2 1/8"	2 1/2"	2"	2"
8-10-8	8'-11"		"	"	"	"	3"	3"	"	"
8-12-8	9'-0"		"	"	"	"	3 1/2"	"	"	"
10-10-10	10'-8"		3'-0"	5' 4"	4'-0"	2'-3"	3"	3"	2 1/2"	3
10-12-10	"		"	"	"	"	4	4"	"	"
10-14¼-10		12'-5"	"	"	"	"	"	5"	"	"
10-16¼-10		"	"	"	"	"	5"	"	"	"
12-12¼-12		14'-3"	3'-9"	6-0	5'-0"	2'-7"	3 1/2"	4"	3	3 1/2
12-14¼-12		14'-6"	"	"	"	"	4"	5"	"	"
12-16¼-12		14'-7"	"	"	"	"	5"	6"	"	"
12-18¼-12		14'-9"	"	"	"	"	6"	7"	"	"

Dimensions of Class "NF-1" Compressors, all Standard Sizes and Types

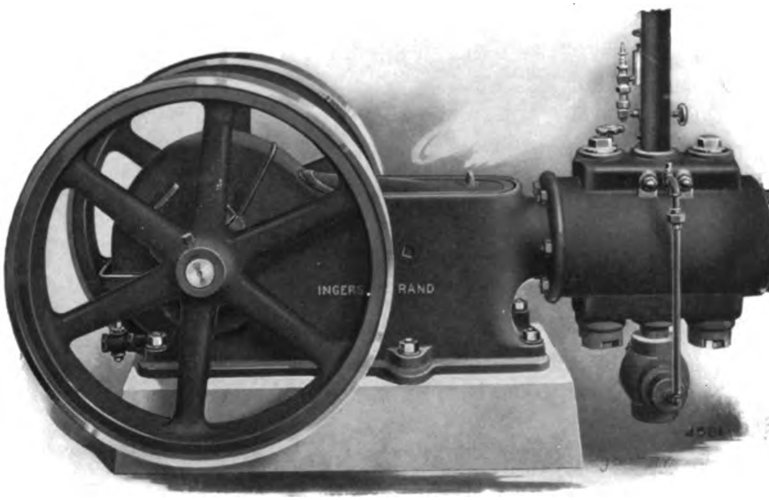
Form 512

Class "NF-1" Straight Line Steam Driven Air Compressors

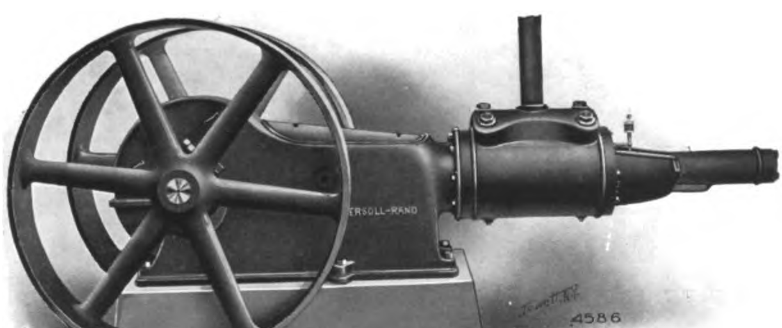
INSTRUCTIONS FOR
INSTALLING AND OPERATING
WITH
DUPLICATE PART LIST

INGERSOLL-RAND
COMPANY
11 BROADWAY
NEW YORK

October, 1910



Standard Class "NE-1" Compressor with "Direct Lift" Inlet and Discharge Valves: Air Cylinders up to and including 12-inch Diameter



Standard Class "NE-1" Compressor with "Hurricane-Inlet" and "Direct Lift" Discharge Valves, used on the Larger Sizes: Air Cylinders 12¼ inches in Diameter and Larger

General Instructions Covering the Installation and Operation of Ingersoll-Rand

Class "NE-1" Air Compressors

These instructions are given for the purpose of assisting in the proper installation of the compressor and to give the operator a clear understanding of the manner in which the several parts perform their duties. For this reason these pages should be read carefully before doing any work on the compressor outfit.

LOCATION

If possible locate the compressor in a clean, light situation with room all around it so that it can be readily inspected and kept clean. If the air is taken into the cylinder directly from the room, see that there is no dust or dirt near the intake where it can be drawn in with the air. A small amount of dust constantly passing into the cylinder will often cause very rapid wearing of the valves and piston. A better arrangement is to run a pipe from the cylinder outside the building and up so as to take the air in some eight or ten feet above the ground. The top should be covered and protected by a wire screen so that rain or large particles of anything cannot be drawn in.

The size of the pipe should be larger, the longer it is. A good rule is to increase it one inch in diameter over the size at the compressor for every ten feet in length. Wood is not a good material for it unless lined with tin, as cracks soon develop through which dust and dirt are free to enter.

AIR RECEIVER

The air receiver, or tank, should be placed as close to the compressor as possible so the discharge pipe is kept short. Never place a valve in the line between compressor and receiver as there is a possibility of starting the compressor with this valve closed, in which case as the air cannot escape an explosion will result.

If the compressor stands near the wall it is a good plan to place the receiver outside the building where it has an opportunity to radiate some of the heat.

The receiver is provided with a blow-off cock near the bottom and it should be drained from time to time.

See that the safety valve is in working order and test it occasionally by lifting the lever or raising the pressure to the blowing-off point.

FOUNDATION

Foundations are now usually built of cement concrete and this is preferable to anything else, though if more convenient brick or stone may be used; but cement mortar should be used in any event and lime mortar avoided.

While the compressor is entirely self-contained, all machinery has a certain vibration and it is the place of the foundation to absorb this, so be sure to make it amply large.

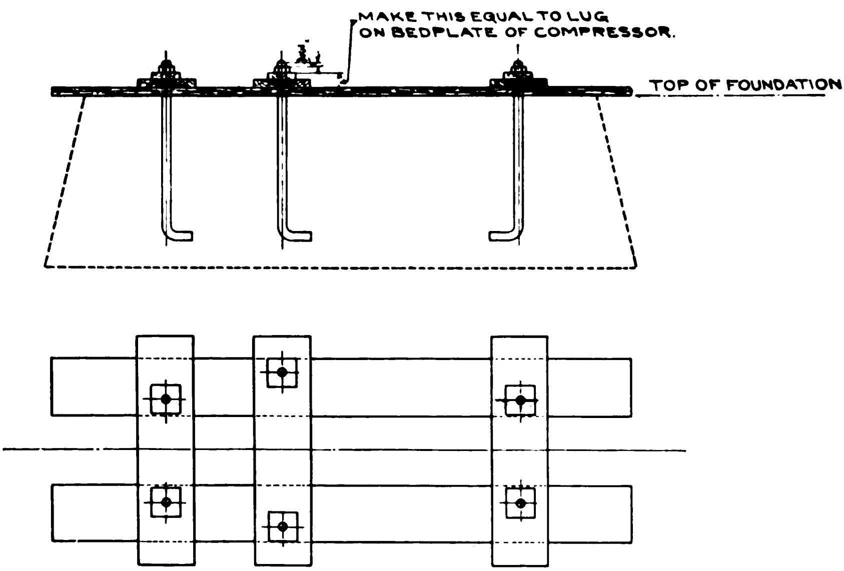
Plans are supplied giving all dimensions and locating all bolt holes, but these plans assume that the foundation is being built upon fairly solid ground. If the bottom is soft, or otherwise insecure, it is advisable to place beneath the foundation proper a footing course 6 inches to 9 inches deep, and a foot or more larger all around.

The best way to locate the foundation bolts is to build a wooden template of boards, something as shown below, and support it in position so that the foundation can be built below it.

In building foundations two mistakes are often made. First, the bolts are built in solidly, with no allowance for moving them to suit slight differences between the hole in the bedplate and those in the template; and second, the foundation is built so high that the bolts do not project far enough to pass all the way through the nut.

All bolts should have large holes built around them so that their tops can be moved an inch or so in any direction, and the easiest way to accomplish this is to slip over each bolt a square wooden box about 2½ inches inside or a piece of old 2-inch or 2½-inch pipe. The wooden box should be withdrawn when foundation is finished and to assist in this it can be made tapering, say 1 inch smaller at bottom than at top. The iron pipe may be left in. In either case after the compressor is set, the holes should be filled with grout or thin cement.

To insure the proper height of bolts above foundation, blocks should be placed upon the top of the template boards to make the total thickness of wood equal to the thickness of lug on bedplate, as shown on plan.



4814

The bolts may be hung from the template and nuts placed on top allowing ¾ inch of bolt to project above the nut. This will allow for levelling the compressor and grouting it upon the foundation.

When compressor is in place, level it and line it carefully by means of wooden wedges or liners at the four corners, and draw the nuts lightly down upon the bolts.

Build a dam about two inches high around the bedplate and pour in sufficient grout to fill all the space between foundation and bedplate. This grout should also fill the space around the foundation bolts.

Allow this cement to harden a few days before finally drawing the nuts down firmly upon the bolts.

STEAM PIPING

In running the steam piping see that it does not drain the main steam pipe. The best plan is to take the steam from the top of the main steam line so that the compressor will only get dry steam. It is advisable to place a valve in the line in addition to the regular throttle valve, so that steam may be shut off at any time should the throttle leak or be out of order.

Make up the steam, exhaust and drain piping carefully so that the joints may remain tight, as otherwise it is impossible to keep the compressor neat.

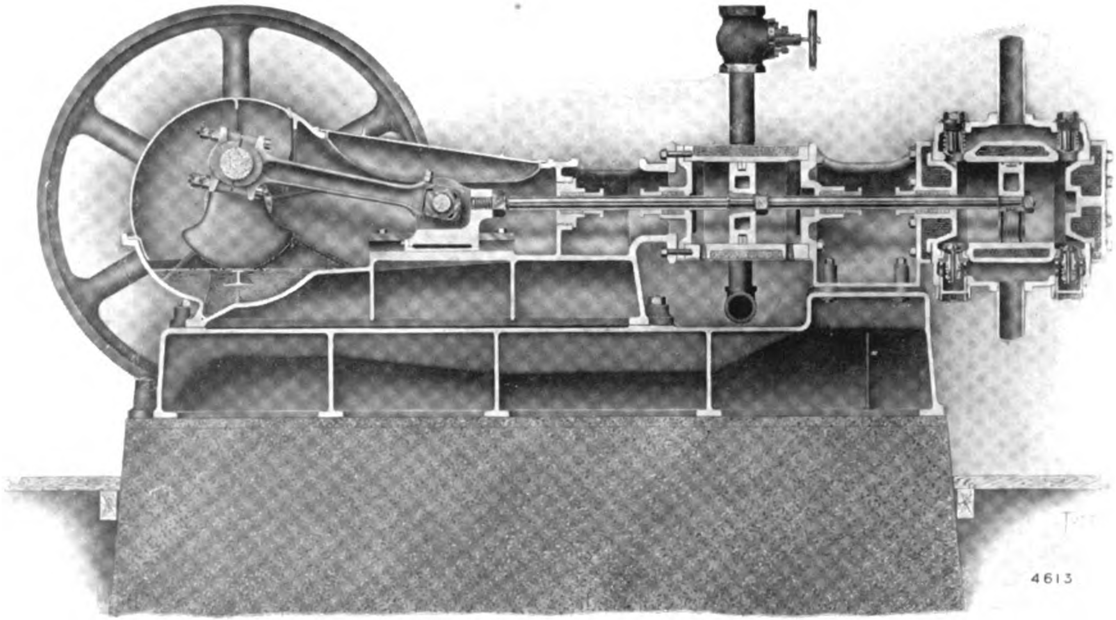
LUBRICATION

This compressor is lubricated by the splash or bath system. The crank case is enclosed and carries a quantity of oil into which the crank and connecting rod dip at every revolution. The crank is also provided with two oil scoops, which, dipping into the oil, throw it all over the interior of the case. A portion of it runs down into the oil holes in the main bearing caps and out along them, finally falling into the oil pockets on the outside of the bed from which it returns by a suitable hole to the crank case. Other portions of it are thrown back over the crosshead, thoroughly flooding these parts. The oil to be used can be any good machine or engine oil that is of a medium density, such as Atlantic Red Engine Oil. A sample can is sent out with each compressor to give an idea of what should be used.

The amount needed to fill the crank case to the proper height is as follows:

6″	Stroke	5 quarts
8″	"	3 gallons
10″	"	5 "
12″	"	9 "

This should be replenished from time to time and occasionally drained off and filtered, or strained through a thick woolen cloth, at the same time wiping out the bottom and corners of the crank case to remove any sediment that may have settled. A convenient way to ascertain if the crank case contains the proper amount of oil is to observe the height in the oil pockets below the main bearing. When the compressor is not running and all the oil has drained back to its level it should stand in the pockets about one-half inch below the point at which it would overflow.



Longitudinal Section of "Direct Lift" Inlet and Discharge Valve Type of Class "NF-1" Compressor

Have regular times for inspecting the height of the oil and remember that while with the proper amount the lubrication is perfect, and all bearings drenched with a flood of oil, yet, if the oil level is allowed to fall to where the scoops cannot reach it, all lubrication ceases and the bearings will soon be ruined.

On larger sizes provided with "HURRICANE-INLET" valves, the gland around the inlet pipe is formed with a large reservoir packed with wool. This should be oiled from time to time, saturating the wool with all the oil it will retain. The wool should be occasionally removed and cleansed, and repacked should it show a tendency to harden where rubbed by the pipe.

The air cylinder is oiled by means of a sight-feed lubricator which may be adjusted to feed the requisite amount. This varies with the size of the cylinder from one drop in two minutes for a 6 x 6-inch cylinder, to two drops per minute for an 18¼ x 12-inch. A very small amount is required, as the oil is not washed out of an air cylinder as it is from a steam cylinder.

The inlet and discharge valves should be removed occasionally and cleaned, and by observing them it can be determined whether the cylinder is receiving the proper amount of oil. The surfaces should show a greasy appearance and not dry.

A special oil must be used in the air cylinder, as the heat of the compressed air is very high and decomposes the ordinary machine oils, not only forming carbon and sooty deposits on the valves and walls but also forming explosive gases which are dangerous and liable to cause explosions.

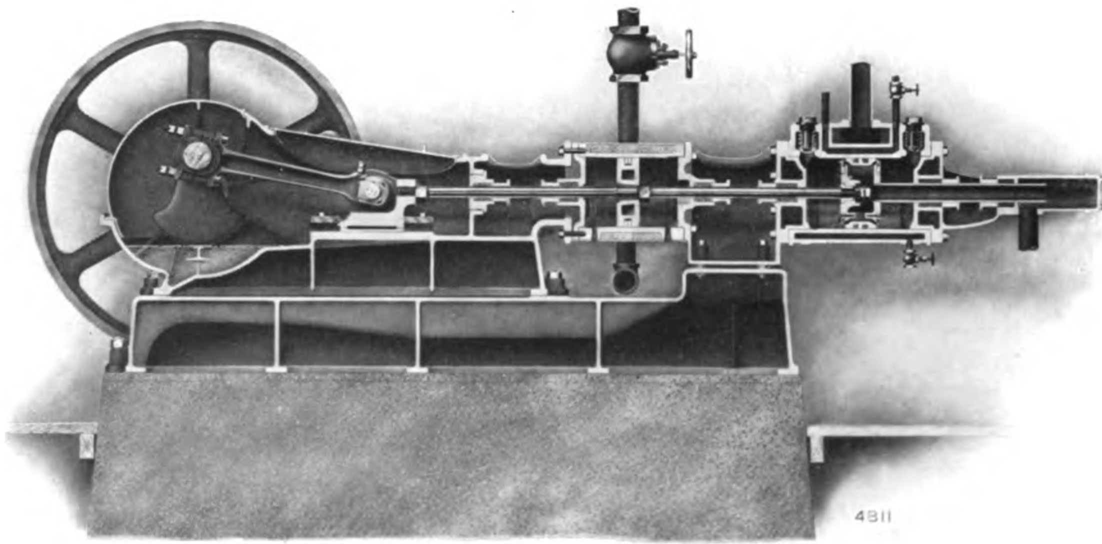
NEVER USE KEROSENE OR COAL OIL IN AN AIR CYLINDER TO CLEAN IT OUT. THIS IS A VERY DANGEROUS PRACTICE AND SHOULD BE ABSOLUTELY PROHIBITED. A good way to clean the cylinder is to fill the lubricator occasionally with strong soapsuds or soda water, allowing this to feed freely. This is very effective but oil should always be fed again before shutting down, to prevent the polished interior surfaces from rusting. For use in air cylinders we recommend that care be taken to provide the necessary supply of oil similar to the sample supplied with the compressor, as this has been found to be the best suited to the purpose.

Use a good quality of steam cylinder oil in the steam cylinder and see that your lubricator is always in working order.

WATER PIPING

Each air cylinder is provided with inlet and outlet, and drain openings in the water jacket. The controlling valve should be placed on the water inlet, and the outlet should if possible be open, the water falling into an open pipe end or funnel so that it can be seen at a glance whether water is passing through the jacket or not.

If desired, the circulating water may be operated in a closed circuit, being used for other purposes after passing through the compressor. The water pressure in the jacket should never exceed 50 lbs. per square inch unless special attention has been called to it at the time compressor was ordered.



Longitudinal Section of Standard Class "NF-1" Compressor with "Hurricane-Inlet" and "Direct Lift" Discharge Valves

Be careful to drain the cylinder thoroughly if it is to be allowed to stand in a freezing temperature, as water freezing in the jacket or heads will certainly crack them sooner or later. Every fall, as soon as cold weather approaches, many cylinders are broken in this manner.

Occasionally remove the back head and inspect the water spaces to see that they are not stopped up with sediment and mud. All water spaces in heads and jackets should be kept free by washing out as often as found necessary.

INLET AND DISCHARGE VALVES

These valves should be removed at regular intervals to see that things are in good working condition. A broken spring may greatly reduce the capacity of the compressor.

The "Direct-Lift" inlet valves used on the smaller sizes are always amply lubricated, as they lie at the bottom of the cylinder; but the discharge valves are more apt to become dry. The plug upon which the valve is carried should show a well-oiled surface, a dry appearance indicating lack of oil or a poor quality of it. The "Hurricane-Inlet" valves in larger sizes are oiled from the cylinder lubricator.

VALVES

Inspect the seat of both inlet and discharge valves periodically. If they show indications of wear or do not make a perfectly tight seat they should be ground in place.

Should the discharge valve seats in the cylinder become badly worn, the Ingersoll-Rand Co. can lend a hand reamer or reseating tool with which the seats may be refaced.

When this is done it is usually advisable to insert new valves.

This refacing of the valve seats is rarely necessary if the compressor is furnished with good clean air; but a little dust or grit will soon cause excessive wear.

All discharge valves have a small hole immediately above the flange or seat, except that on compressors fitted with the "A-28" type of regulator those valves to which the regulator is connected do not have these holes. Care should be taken when ordering valves for a compressor fitted with this regulator to specify whether valves are wanted "drilled" or "not drilled" and whether caps are to be tapped or not tapped.

ADJUSTMENT OF CONNECTING ROD

The crosshead end of the connecting rod is adjusted by drawing up on the wedge bolt passing up through the rod, and the crank pin end is tightened by removing one or more of the sheet metal liners between the rod and the cap or end.

After making an adjustment be sure to lock securely all bolts and nuts so that they will not work loose.

GASKETS

In replacing the gaskets between the heads and cylinder use rubber $\frac{1}{16}$" thick. A thicker piece will increase the clearance volume and reduce the capacity of the compressor, while a thinner sheet will not allow suffi-

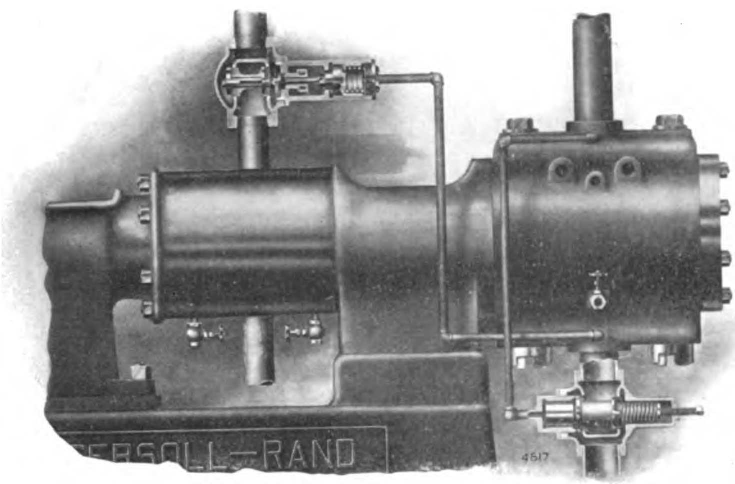
cient clearance between the heads and piston. Be careful to use a packing that is oil-proof, as otherwise the oil and high temperature will soon destroy it.

DUPLICATE PART LIST

On the insert at end of book are given sectional views of the two types of this compressor, both "Direct-Lift" and "Hurricane-Inlet" valve patterns.

When ordering parts examine the cut carefully and specify the parts wanted by name and number, being sure to give also the serial number of the compressor, which is stamped upon the brass plate attached to the cylinder.

The parts are not only numbered individually but they will be found to be also grouped, as it frequently happens that a connecting rod or an air cylinder or other part is wanted with all parts which are fitted to it. When parts complete are ordered they are assembled and all their constituent parts fitted together by us at the shop.



Showing arrangement of piping for "A-35" Air and "A-36" Steam Regulators, Standard on "NF-1" Compressors

REGULATION

The standard regulator is the "A-35" Air Regulator used in conjunction with the "A-36" Steam Regulator, the one closing off the air inlet while the other at the same time shuts off the steam.

The "A-35" Air Regulator consists of a body containing a double-disc valve and air piston which is forced shut by air pressure behind the piston and opened as the pressure falls by a spring.

The only adjustment necessary is to screw the adjusting screw in for a higher pressure or to screw it out if a lower pressure is wanted.

The standard spring will give a range of from 50 to 100 lbs. per square inch. If a lower pressure is desired a low pressure spring must be substituted.

A-39 REGULATOR

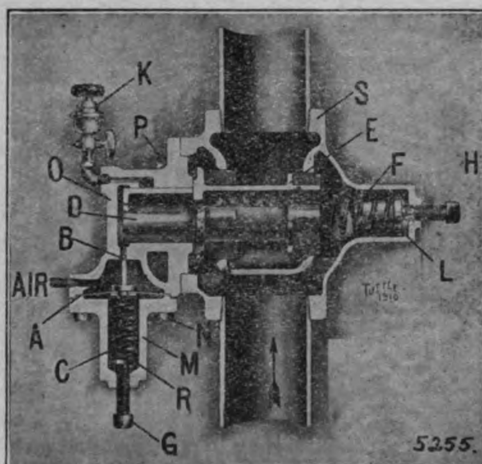
DESCRIPTION AND INSTRUCTIONS.

This Regulator is to be placed on the air intake to the compressor and operates by shutting off the inlet passage and thus preventing any air from entering the compressor.

In putting it on a compressor attach it by piping to the intake connection on the air cylinder so that the air passes upward through it in the direction of the arrow.

The regulator is operated by air piped from the receiver and entering the connection marked "air." This piping should run to the receiver or to the pipe line some distance from the compressor where the air is somewhat cooler and the pressure more steady. Do not connect to the bottom of a pipe where oil or dirt passing along the pipe will fall in.

Air entering the regulator here presses the diaphragm "A" back against the diaphragm spring "C" and when it reaches a high enough pressure to overcome the spring the diaphragm is forced back opening



the needle valve "B" and allowing air to pass behind the air cylinder piston "D." This forces the regulator valve "E" shut and cuts off the air entering the compressor.

When the air pressure in receiver falls slightly the diaphragm spring "C" closes the needle valve "B" and the air behind piston "D" slowly leaks out allowing the regulator valve spring "F" to force the regulator valve "E" open and thus again supply air to the compressor. Adjustment for various air pressures is made by adjusting screw "C."

The set screw "H" behind regulator valve spring "F" need only be set up sufficiently to force the main valve open and does not require alteration for change of pressure.

See that the oil cup "K" is filled occasionally and open the regulator from time to time and clean it out as may be found necessary.

Symbol	Name of Parts	Symbol	Name of Parts
A	Diaphragm } Always shipped together	K	Lubricator
B	Needle valve } Always shipped together	L	Regulator valve spring washer
C	Diaphragm spring	M	Spring case
D	Air cylinder piston	N	Spring case tap bolts
E	Regulator valve	O	Air cylinder
F	Regulator valve spring	P	Air cylinder tap bolts
G	Diaphragm spring adjusting screw	R	Diaphragm spring washer
H	Regulator valve spring adjusting screw	S	Regulator body

any sediment that may have settled. A convenient way to ascertain if the crank case contains the proper amount of oil is to observe the height in the oil pockets below the main bearing. When the compressor is not running and all the oil has drained back to its level it should stand in the pockets about one-half inch below the point at which it would overflow.

Have regular times for inspecting the height of the oil and remember that while with the proper amount the lubrication is perfect, and all bearings drenched with a flood of oil, yet, if the oil level is allowed to fall to where the scoops cannot reach it, all lubrication ceases and the bearings will soon be ruined.

On larger sizes provided with "HURRICANE-INLET" valves, the gland around the inlet pipe is formed with a large reservoir packed with wool. This should be oiled from time to time, saturating the wool with all the oil it will retain. The wool should be occasionally removed and cleansed, and repacked should it show a tendency to harden where rubbed by the pipe.

The air cylinder is oiled by means of a sight-feed lubricator which may be adjusted to feed the requisite amount. This varies with the size of the cylinder from one drop in two minutes for a 6 x 6-inch cylinder, to two drops per minute for an 18¼ x 12-inch. A very small amount is required, as the oil is not washed out of an air cylinder as it is from a steam cylinder.

The inlet and discharge valves should be removed occasionally and cleaned, and by observing them it can be determined whether the cylinder is receiving the proper amount of oil. The surfaces should show a greasy appearance and not dry.

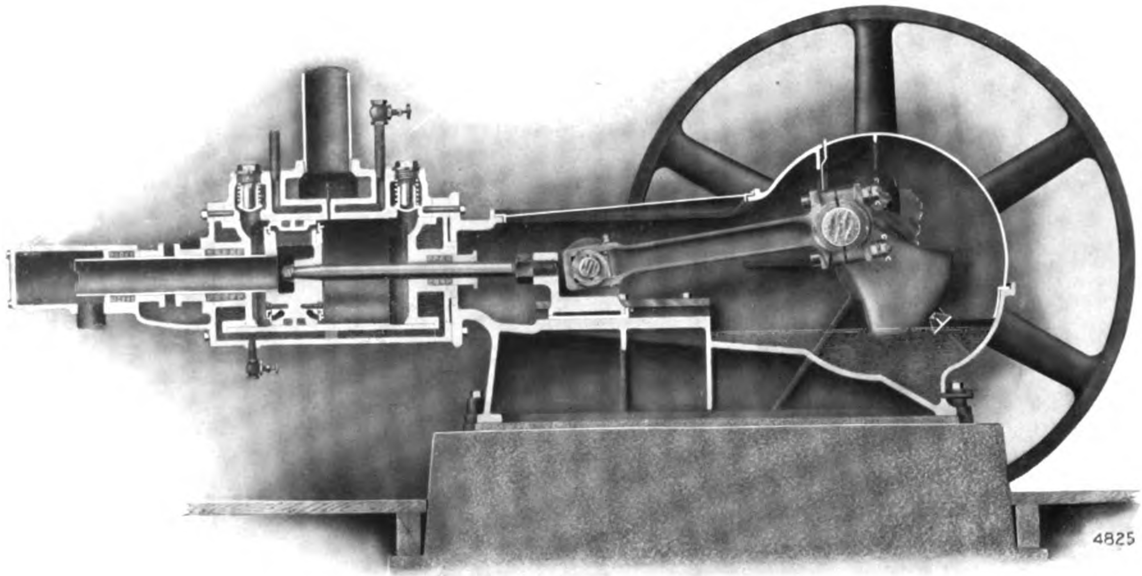
A special oil must be used in the air cylinder, as the heat of the compressed air is very high and decomposes the ordinary machine oils, not only forming carbon and sooty deposits on the valves and walls but also forming explosive gases which are dangerous and liable to cause explosions.

NEVER USE KEROSENE OR COAL OIL IN AN AIR CYLINDER TO CLEAN IT OUT. THIS IS A VERY DANGEROUS PRACTICE AND SHOULD BE ABSOLUTELY PROHIBITED. A good way to clean the cylinder is to fill the lubricator occasionally with strong soapsuds or soda water, allowing this to feed freely. This is very effective but oil should always be fed again before shutting down, to prevent the polished interior surfaces from rusting. For use in air cylinders we recommend that care be taken to provide the necessary supply of oil similar to the sample supplied with the compressor, as this has been found to be the best suited to the purpose.

WATER PIPING

Each air cylinder is provided with inlet and outlet, and drain openings in the water jacket. The controlling valve should be placed on the water inlet, and the outlet should if possible be open, the water falling into an open pipe end or funnel so that it can be seen at a glance whether water is passing through the jacket or not.

If desired, the circulating water may be operated in a closed circuit, being used for other purposes after passing through the compressor.



Longitudinal Section of Standard Class "NE-1" Compressor with "Hurricane-Inlet" and "Direct Lift" Discharge Valves

The water pressure in the jacket should never exceed 50 lbs. per square inch unless special attention has been called to it at the time compressor was ordered.

Be careful to drain the cylinder thoroughly if it is to be allowed to stand in a freezing temperature, as water freezing in the jacket or heads will certainly crack them sooner or later. Every fall, as soon as cold weather approaches, many cylinders are broken in this manner.

Occasionally remove the back head and inspect the water spaces to see that they are not stopped up with sediment and mud. All water spaces in heads and jackets should be kept free by washing out as often as found necessary.

REGULATION

The standard regulator for these compressors is the "A-35" type, being a choking controller applied to the intake. It consists of a body containing a double-disk valve and air piston which is forced shut by air pressure behind the piston and opened as the pressure falls by a spring. The only adjustment necessary is to screw the adjusting screw in for a higher air pressure or to screw it out if a lower pressure is wanted. The standard spring will give a range of from 50 to 120 lbs. per square inch. If a lower pressure is desired, a low pressure spring must be substituted.

Occasionally unscrew the regulator air cylinder and remove the piston for cleaning, as dust and dirt may accumulate and prevent the free action of the regulator.

In order to get a certain amount of pulsation to the air in the regulator cylinder which helps keep the regulator "lively" and prompt to act, it is connected to the air discharge of the cylinder. If the valve in the regulator seems to hammer it may be necessary to partially close the cock in the piping. This will usually indicate, however, that the piping between compressor and receiver is not large enough to carry the air off freely.

INLET AND DISCHARGE VALVES

These valves should be removed at regular intervals to see that things are in good working condition. A broken spring may greatly reduce the capacity of the compressor.

The "Direct-Lift" inlet valves used on the smaller sizes are always amply lubricated, as they lie at the bottom of the cylinder; but the discharge valves are more apt to become dry. The plug upon which the valve is carried should show a well-oiled surface, a dry appearance indicating lack of oil or a poor quality of it. The "Hurricane-Inlet" valves in larger sizes are oiled from the cylinder lubricator.

VALVES

Inspect the seat of both inlet and discharge valves periodically. If they show indications of wear or do not make a perfectly tight seat they should be ground in place.

Should the discharge valve seats in the cylinder become badly worn, the Ingersoll-Rand Co. can lend a hand reamer or reseating tool with which the seats may be refaced.

When this is done it is usually advisable to insert new valves.

This refacing of the valve seats is rarely necessary if the compressor is furnished with good clean air; but a little dust or grit will soon cause excessive wear.

All discharge valves have a small hole immediately above the flange or seat, except that on compressors fitted with the "A-28" type of regulator those valves to which the regulator is connected do not have these holes. Care should be taken when ordering valves for a compressor fitted with this regulator to specify whether valves are wanted "drilled" or "not drilled" and whether caps are to be tapped or not tapped.

ADJUSTMENT OF CONNECTING ROD

The crosshead end of the connecting rod is adjusted by drawing up on the wedge bolt passing up through the rod, and the crank pin end is tightened by removing one or more of the sheet metal liners between the rod and the cap or end.

After making an adjustment be sure to lock securely all bolts and nuts so that they will not work loose.

GASKETS

In replacing the gaskets between the heads and cylinder use rubber $\frac{1}{16}''$ thick. A thicker piece will increase the clearance volume and reduce the capacity of the compressor, while a thinner sheet will not allow sufficient clearance between the heads and piston. Be careful to use a packing that is oil-proof, as otherwise the oil and high temperature will soon destroy it.

DUPLICATE PART LIST

On the following insert are given sectional views of the two types of this compressor, both "Direct-Lift" and "Hurricane-Inlet" valve patterns; and facing it is a duplicate part list.

When ordering parts examine the cut carefully and specify the parts wanted by name and number, being sure to give also the serial number of the compressor, which is stamped upon the brass plate attached to the cylinder.

The parts are not only numbered individually but they will be found to be also grouped, as it frequently happens that a connecting rod or an air cylinder or other part is wanted with all parts which are fitted to it. When parts complete are ordered they are assembled and all their constituent parts fitted together by us at the shop.

LIST OF DUPLICATE PARTS OF CLASS "NE-1" COMPRESSOR

NO.	NAME OF PART
1	**Bedplate, Complete** (Parts 2 to 10)
2	Bedplate (Bare) including Parts 8 and 9
3	Bedplate Oil Guard
4	Bedplate Cover
5	Bedplate Drain Cocks
6	Bedplate Guide Bars
7	Bedplate Guide Bar Tap Bolts
8	Main Bearing Caps (Babbitted)
9	Main Bearing Cap Studs and Nuts
*10	Plug for Crosshead Pin Hole
20	**Crank Shaft and Belt Wheels, Complete** (Parts 21 to 26)
21	Crank Shaft
22	Fly Wheel (Narrow)
23	Belt Wheel (Wide)
*24	Belt and Fly Wheel Keys
*25	Belt and Fly Wheel Key Set Screws
26	Oil Dipper
37	**Connecting Rod, Complete** (Parts 38 to 43)
38	Connecting Rod and Cap (Babbitted)
39	Connecting Rod Bolt with Nuts (Lock Washer and Cotter Pin when used)
42	Connecting Rod Brasses (Two Pieces)
43	Connecting Rod Brasses Key with Nut and Washer
54	**Crosshead, Complete** (Parts 55 to 59)
55	Crosshead (Bare)
56	Crosshead Gib
57	Crosshead Tap Bolts
58	Crosshead Tap Bolt Lock Washer
59	Crosshead Pin with Washer and Nut or Bolt
135	**Air Cylinder, Complete** (Parts 136 to 197)
136	Air Cylinder (Bare) including Parts 138 and 140
138	Back Head Studs and Nuts
139	Front Head
140	Front Head Studs and Nuts
141	Front Head Gland
142	Front Head Gland Studs and Nuts
147	Back Head (With Extension Bracket When Used)
148	Back Head Bracket Cover
149	Back Head Bracket Cover Tap Bolts
150	Back Head Bracket Plain Gland
*151	Back Head Bracket Plain Gland Studs and Nuts
152	Back Head Waste Packed Gland
*153	Back Head Waste Packed Gland Studs and Nuts
160	**Inlet Valve, Complete** (Parts 161 to 163)
161	Inlet Valve with Collar and Pin
162	Inlet Valve Guide
163	Inlet Valve Spring
164	Inlet Valve Cap
165	Lock Nut
170	**Discharge Valve, Complete** (Parts 171 and 173
171a	Discharge Valve (Regular, Drilled)
171b	Discharge Valve (For Use With A-28 Regulator, not drilled)
172a	Discharge Valve Cap (Regular Not Tapped)
172b	Discharge Valve Cap (Tapped for A-28 Regulator Pipe)
173	Discharge Valve Spring
174	Air Piston, Complete (Parts 175 to 181 for Hurricane-Inlet Cylinders)—(Parts 175, 176, 177 for Poppet Inlet Cylinders)
175	Air Piston (Bare)
176	Air Piston Rings
177	Air Piston Springs
178	Hurricane-Inlet Valve
179	Hurricane-Inlet Valve Guide
180	Hurricane-Inlet Valve Guide Screws
181	Hurricane-Inlet Valve Guide Screw Lock Washer
182	Piston Inlet Pipe
190	Air Piston Rod
193	Piston Rod Nut for Air Piston
197	Piston Rod Nut for Crosshead
200	Air Cylinder Lubricator
221	**Air Regulator, Complete** (Parts 221 to 227)
222	Air Regulator Body
223	Air Regulator Cylinder
224	Air Regulator Valve
225	Air Regulator Valve Spring
226	Air Regulator Valve Spring Washer
227	Air Regulator Valve Set Screw
235	Complete Set of Packing for all Stuffing Boxes
239	Air Cylinder Front Head Packing
240	Air Cylinder Back Head Packing
241	Extension Bracket Packing

WRENCHES: In ordering wrenches give numbers and name of bolt or stud for which it is wanted. Or order by number which is stamped on each wrench.

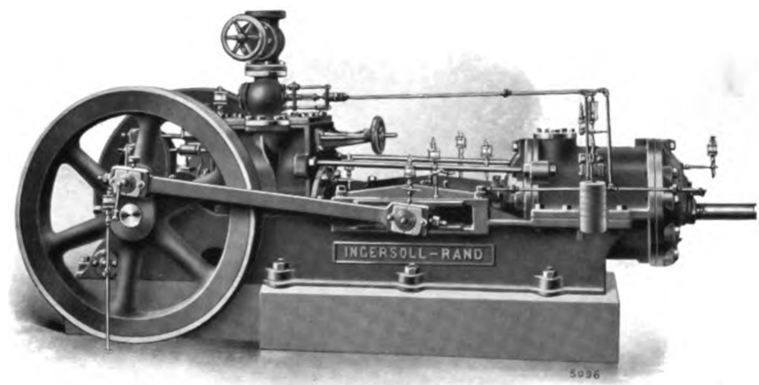
NOTE: In ordering parts from above list always give both *number and name* of parts wanted and give the serial number of the compressor which is stamped on a brass plate attached to the air cylinder. This number is also stamped on the top edge of air cylinder back head.

***Parts marked thus are not shown on drawing.**

CLASS "A-1" STRAIGHT LINE STEAM DRIVEN SINGLE STAGE AIR COMPRESSORS

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

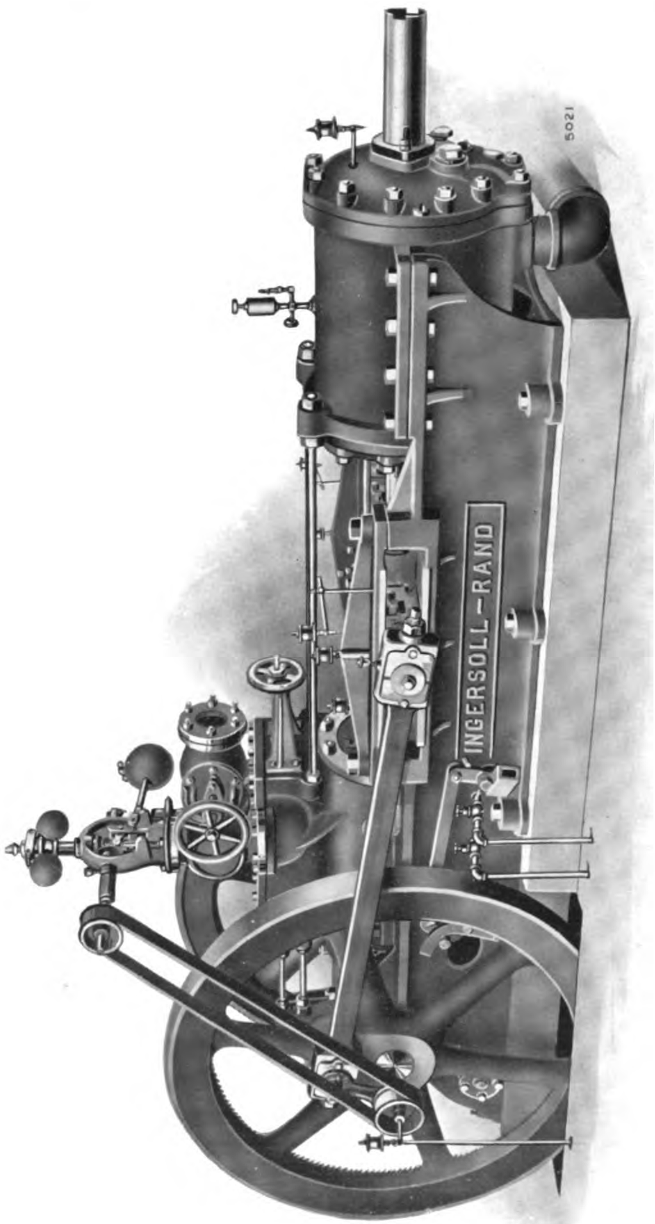
Form No. 3002 September, 1910



Class "A-1" Compressor, Fitted with the "A-14" Steam Regulator and "A-28" Air Unloader: Standard on the Fourteen Smaller Sizes

THE original Class "A" Ingersoll Air Compressor was the pioneer compressor type. Steadily improved with the increasing knowledge of compressor design, this machine in its progressive development has been built in larger numbers and has found a greater variety of applications than any other compressor type. Seldom indeed has a fundamental principle of design received such strong endorsement by a long experience and diversified application.

The Ingersoll-Rand Class "A-1" Compressor, the subject of this pamphlet, is the modern form of the original "A" type, developed to date in every respect. The fundamental straight line principle of direct application of power to load is retained; and the machine as a whole is distinguished by its remarkable

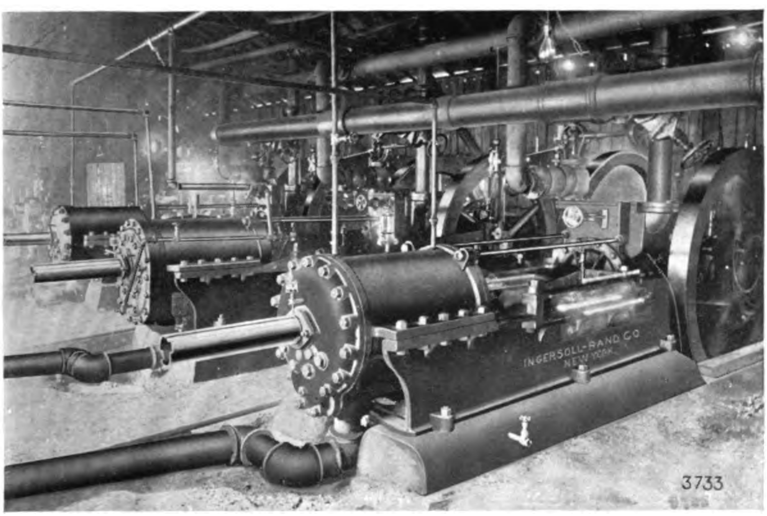


Class "A-1" Compressor, Fitted with the "Air Ball" Governor; Standard on the Thirteen Larger Sizes

simplicity, compactness and self-contained quality. It is a splendid example of rugged strength, sturdy reliability and commercial economy in air compressors.

Some Features of Design

The "A-1" Compressor consists of a simple steam and single stage air cylinder mounted on a main frame, with twin outside-connected fly-wheels. The more notable features of design may be enumerated as follows: high mechanical efficiency due to the simplicity of construction and the generous bearings; positive automatic air valve movements requiring no setting or adjustment; adjustable cut-off steam valves on machines with 14-inch steam cylinders and larger; admission of cool, clean, intake air, by means of the "Hurricane-Inlet" valve and the intake connection; high volumetric and compression efficiency due to the admission of cool air, to the large area of valves and air passages, and to the complete cylinder jacketing bringing about an improved cylinder lubrication and resulting in sustained tightness and freedom from leakage; automatic regulation of speed and air pressure under changing load. The weight of fly-wheels and reciprocating parts is carefully proportioned to give smooth, uniform rotation at all speeds.



Three Class "A-1" Compressors in the Power House of the Alleghany Summit Tunnel on The Tidewater Railway

The Field of the Class "A-1" Compressor

In the earlier period of compressed air development the Class "A-1" Compressor, or its earlier types, found application wherever compressed air was needed. It was indeed an "all-around" machine, doing good work under all conditions. But the increasing use of compressed air in almost every branch of industry, and a better understanding of the principles of compressed air economy, have brought about an increasing demand for the larger and more costly, but more economical, duplex types of air compressors. This has reduced the use of the straight line machine in cases where relatively large capacity and high economy are demanded.

There still exists, however, a constantly enlarging field in which the need is for machines of moderate cost and capacity, easy of installation and operation, and of "all-around" good economy under heavy service. Such machines are frequently only the forerunners of larger, more efficient compressors installed later to meet the increasing requirements for air.

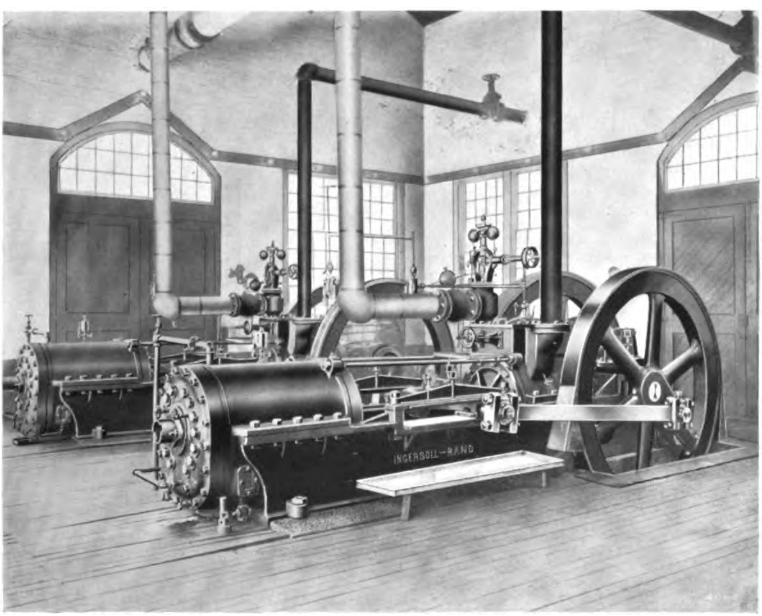
This demand comes from several sources. The coal and metal mining fields call for relatively small, self-contained units, easily transported and set up, and not requiring a skilled attendant to run them. The contract trade is continually calling for such machines for temporary or semi-permanent jobs. Frequently this class of work calls for the installation of a number of straight line machines on a single job which are later distributed among several smaller jobs. The industrial field offers places without number where compressed air in comparatively small volumes is economically desirable, yet the conditions make high economy secondary in importance to moderate cost, simplicity and "stand-up" qualities.

These are the fields in which the Class "A-1" Compressor still finds its greatest market. The purchaser, when enlarging his plant, usually gives the order for his later machines to the builder whose simpler type has given him entire satisfaction. The Ingersoll-Rand Company, therefore, builds its "A-1" machines with the same care as to design, materials and workmanship as its larger and more costly types. Their construction has been slighted in no detail whatever.

Single and Two Stage Compression

The economy of any machine is entirely relative—a question of standards determined by the conditions under which that machine is to be used. In the case of air compressors, no one today will deny that two stage compression, when properly carried out, is more economical than single stage compression. Taking two compressors of equal size and stroke, of equal care in design and construction and of approximately the same type, the two stage machine is certainly more economical than the single stage. But other factors may enter into the problem, throwing a different light on the case and materially affecting judgment in the matter.

The Class "A-1" Compressor is intended to meet the conditions of the fields outlined in the preceding section. In these fields the acknowledged higher economy of two stage compressors is not primarily essential. High operating economy necessarily commands a higher first cost of machine to cover the mechanical refinements necessary. Where the work is only temporary in character, or only preliminary to further expansion, the main thing to be sought is simplicity and good general economy. Later

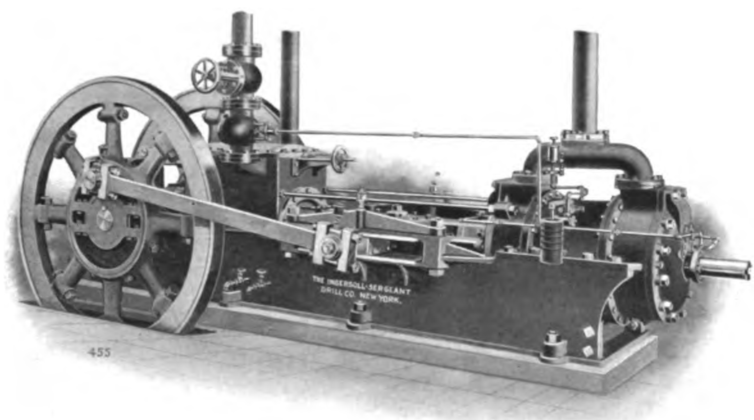


Two Class "A-1" Compressors at the Eleanora Shaft of the Rochester and Pittsburg Coal Co.

developments leading to a permanent plant of larger capacity will justify the larger initial outlay necessary in securing two stage operating economy. This is simply a matter of good business. For this high-duty service there are the Ingersoll-Rand "AA-2" two stage straight line type and the Company's splendid line of duplex compressors. Separate pamphlets cover these machines. But for the conditions for which it is specifically intended there is no better compressor than the Class "A-1."

Simplicity and Compactness

Examination of the illustrations of the "A-1" Compressor reveals the completeness with which all non-essentials have been eliminated. Cumbersome and complicated valve gear is conspicuous by its absence. Connecting rods are of the solid, one-piece locomotive type. Bearings are of generous proportions and



Class "A-1" Sectionalized Air Compressor, Specially Built for Mule-back Transportation

ample provision has been made for proper lubrication. It is hard to discover any possible trouble-making elements in this machine, which is trimmed down to the rugged fundamentals of steady, hard service.

The compact, self-contained character of the "A-1" is another valuable feature. The solid bed-plate or main frame supports the entire machine, which can be moved or transported entire, if necessary. In shipment, the fly-wheels (on the larger sizes) are usually removed and the governor, throttle, etc., boxed. But

there is no "lining up" to be done; this is all done at the shop prior to shipment. Place the compressor on its foundation—level up—grout the joint; that is all that is required for installing. Certain sizes of the "A-1" type can be furnished sectionalized for transportation over difficult trails in inaccessible mountainous districts. Information on these special sectionalized machines will be furnished on request.

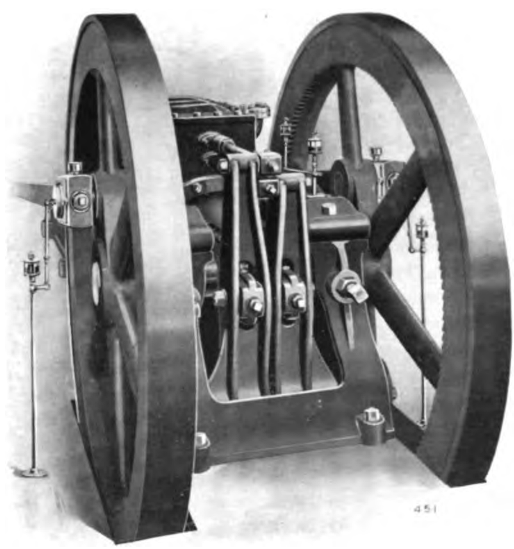
Accessibility

The "A-1" design invites, by its complete accessibility, the care and attention which are so well repaid by their effect on smooth, economical operation. There are no hidden, out-of-the-way parts. Bearings can be inspected while the machine is running. Every part is convenient of access.

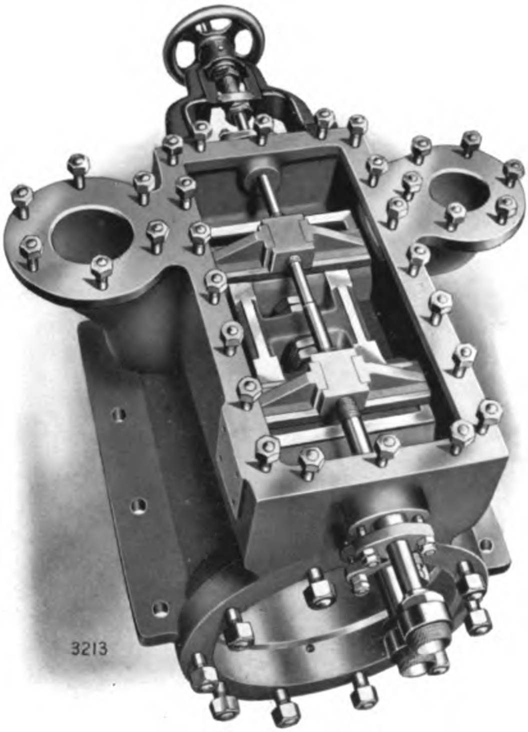
The Driving End

The three smaller sizes of Class "A-1" Compressors have a plain slide or "D" steam valve with a cut-off fixed for average conditions. Larger sizes, of 14-inch steam cylinder diameter and above, have Meyer adjustable cut-off steam valves. On special order and at extra cost, balanced steam valves can be furnished. Steam and exhaust ports and passages are large and free, to avoid wire drawing and back pressure. The best simple steam engine practice is a feature of the steam end.

The peculiar requirements of the field in which the Class "A-1" finds its greatest application have determined the characteristics of the



End View of Class "A-1" Compressor, Showing Rocker Arms and Valve Gear



Top View of Steam Cylinder of Class "A-1" Compressor with Valve Chest Cover Removed, Showing Meyer Cut-off Valves Furnished on the Larger Sizes

steam end. It has been deemed better to use a simple steam cylinder giving a good steam economy and sturdy dependability, than to attempt compounding the steam cylinders, which would necessitate an increase in the number of parts and a greater liability to derangement and loss of economy in the absence of skilled attendants.

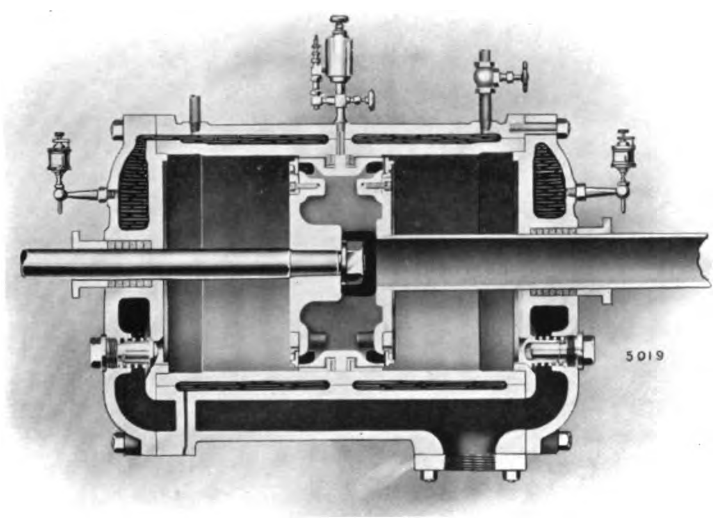
Experience has demonstrated that, in the "rough-and-ready" service for which the Class "A-1" is intended and most generally used, compound steam cylinders and extremely refined steam valve movements are inadvisable. Though theoretically a source of better economy, they soon lose their adjustments and efficiencies and become, instead of an advantage, a positive disadvantage and a source of trouble and expense.

The fly-wheels are balanced and forced on the shaft over a key. On machines of 18-inch stroke and larger, an off-centering

device is provided consisting of a pawl engaging teeth on the inner edge of one of the fly-wheels, which is manipulated by a lever. The function of this device is to turn the compressor over until the cranks are in the proper position for opening the steam throttle.

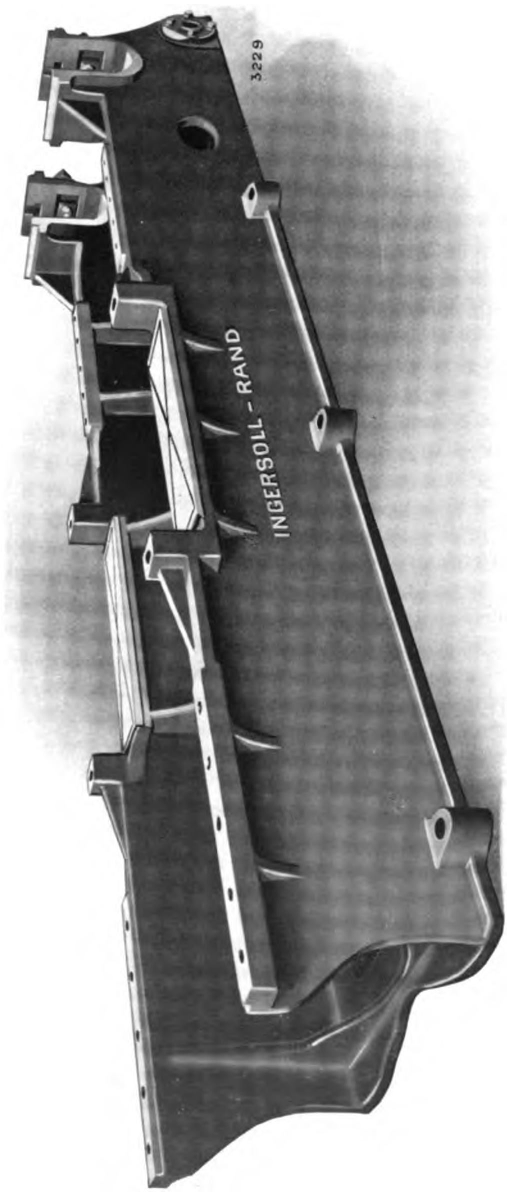
The Air End

The air cylinder of Class "A-1" Compressors is simple, rugged and designed for maximum single stage economy. The space between shell and bore forms an ample water jacket. Suitable margin is provided to permit reboring, if necessary. The heads are strongly ribbed and reinforced, and completely jacketed except where the discharge valves come.

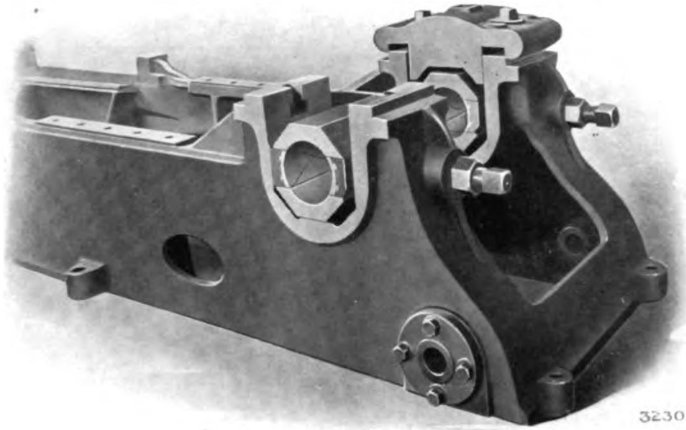


Longitudinal Section through the Air Cylinder of Class "A-1" Compressors, showing "Hurricane-Inlet" Valves, "Cushioned Direct Lift" Discharge Valves, Large Air Passages and Thorough Water Jacketing

Air intake valves are of standard "Hurricane-Inlet" type, an improvement upon the original Piston Inlet valve. Air discharge valves are of the "Cushioned Direct Lift" type. Both of these valves are described in detail in Pamphlet 3001 which will be furnished on request. Further description is therefore omitted at this point. It need only be said that the "Hurricane-Inlet"



Main Frame or Bed-Plate of Class "A-1" Compressor

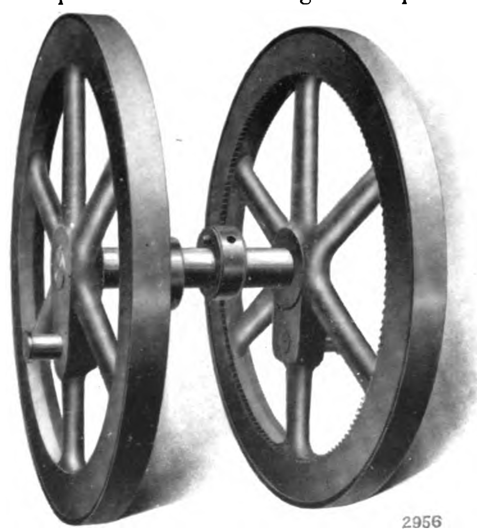


The Main Bearings

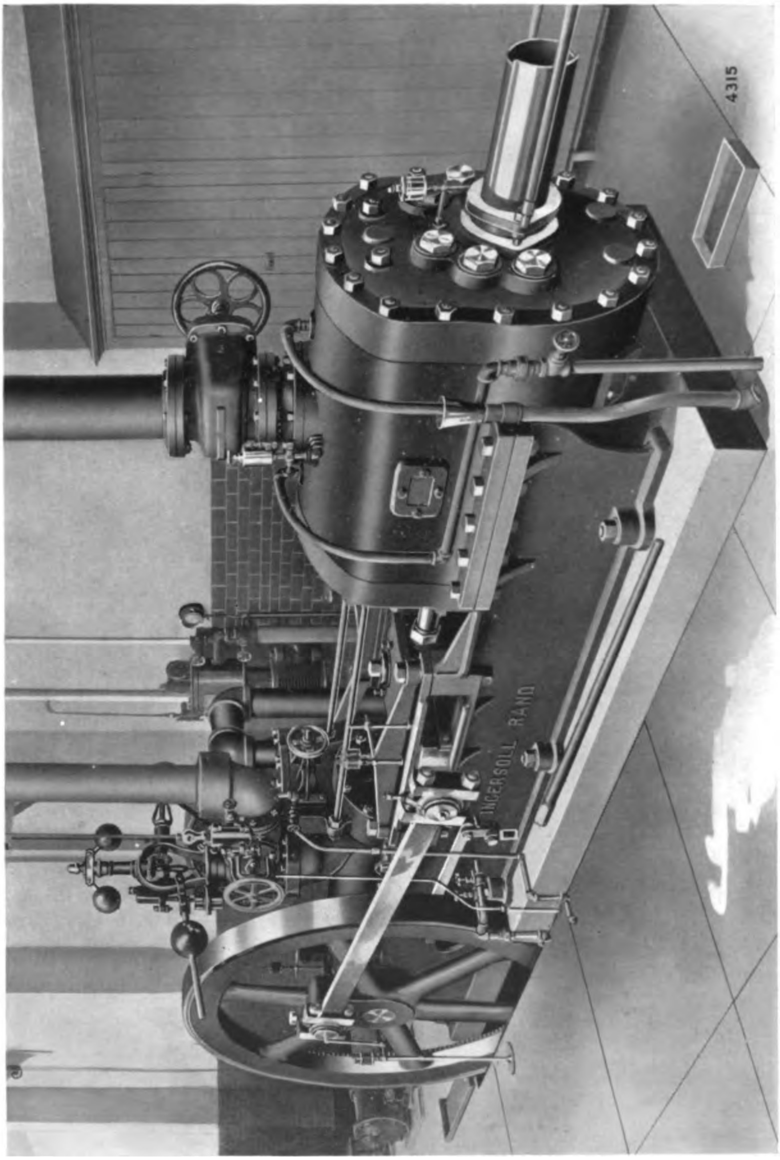
and "Cushioned Direct Lift" discharge valves admit and discharge more air for a given cylinder displacement than any other type of valve, under the operating conditions for which Class "A-1" Compressors are intended.

Some Mechanical Details

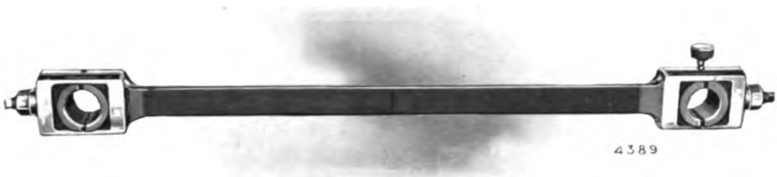
The main frame or bed-plate is a solid casting of box pattern, strongly ribbed and provided with a broad bearing upon the foundation. The joint between steam and air cylinders and main frame is on a line with the axis of the cylinders, so that there is no tendency whatever to buckle or bend. All bolt holes in the bed-plate and in the cylinders are bored at one mounting by means of an accurate metal template. All joints



The Flywheels and Shaft

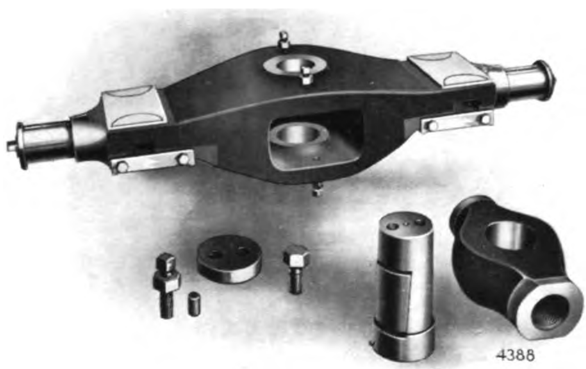


Class "A-1" Compressor at the Plant of the Waltham Watch Co.



A Class "A-1" Connecting Rod

are carefully machined. All bolts uniting cylinders and bed-plate are carefully fitted. As all planing operations are done at one setting, it is impossible to assemble a Class "A-1" Compressor out of line.

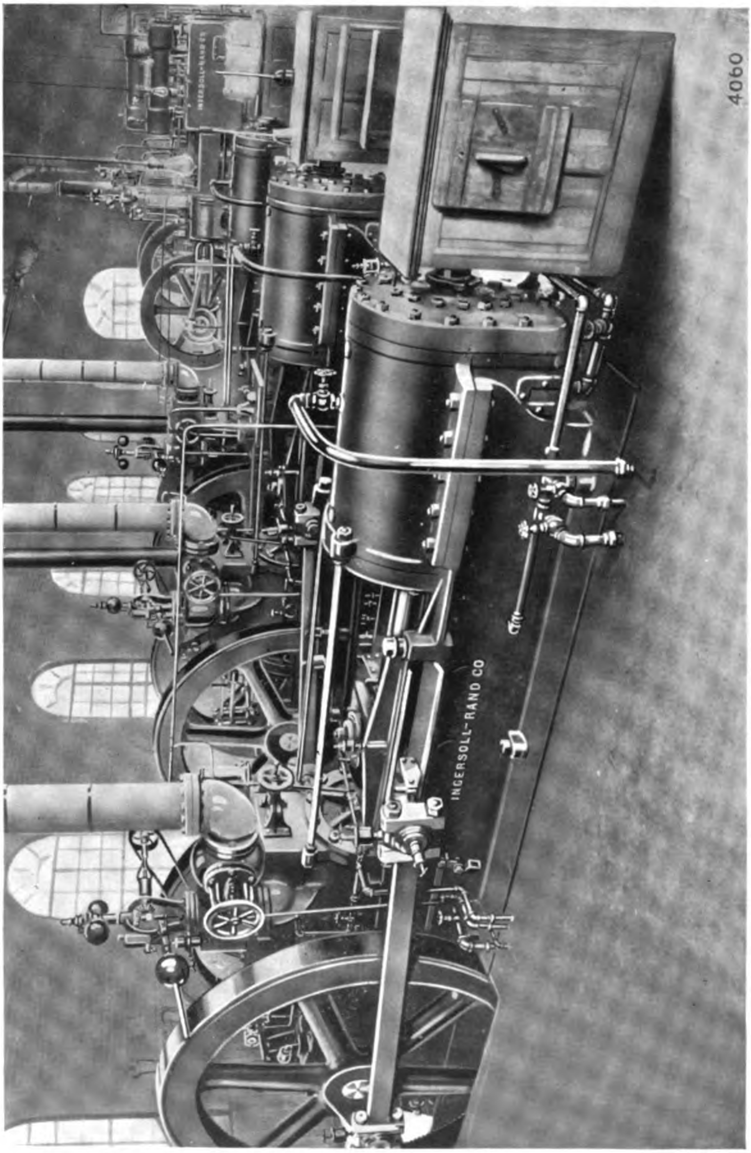


The Crosshead and Swivel Pin

The main bearings are of very rigid type, of ample length and diameter. They are fitted with removable bearing boxes, the top and bottom boxes being of bronze. The side boxes are cast with dove-tails and lined with babbitt. Fore-and-aft adjustment is provided by means of lock bolts. The connecting rods are forged in one piece without welds and fitted with cast boxes lined with babbitt metal. The crosshead is of the compensating or swivel type, with adjustable bronze shoes above and below. The swivel pin is of a new design which provides automatic adjustment under wear and absolutely avoids any hammering.

Regulation

On Class "A-1" Compressors up to and including 18-inch stroke sizes, the standard regulator consists of the "A-28" Air



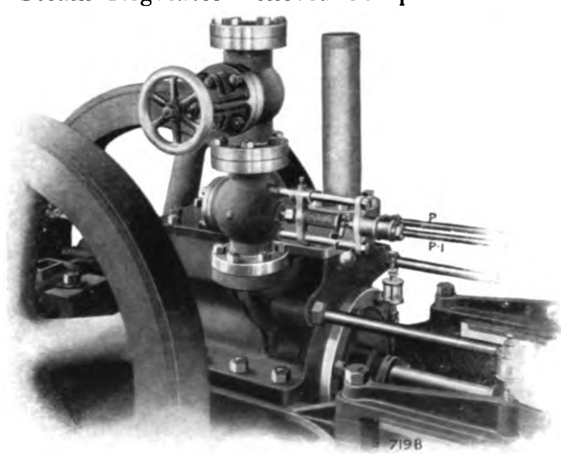
Interior View of Power House of Keystone Coal and Coke Co., showing Class "A-1" Compressors

Unloader combined with the "A-14" Steam Regulator. On larger sizes the "Air Ball" Governor is the standard regulator. For special conditions and where specified on order the "A-28" Air Unloader and the "A-14" Steam Regulator can be furnished on the larger sizes; or the "Air Ball" Governor can be supplied on the smaller sizes.

It is to be understood that the "Air Ball" Governor will regulate a compressor only down to a speed where it will turn over under pressure. In larger sizes this is about half normal speed. When load falls below this point, the excess pressure is blown off through the safety valve.

The "Air Unloader" and "Steam Regulator," on the other hand, completely unload the compressor, so that they provide regulation from full load down to no load.

Where some air—probably about 50 per cent. of full load—is wanted all the time, the "Air Ball" Governor is to be preferred. Where, for part of the time, no air at all is required, the "Air Unloader" and "Steam Regulator" should be specified. This latter condition usually holds where small compressors only are required. Hence this latter type of regulator is considered standard on small sizes of "A-1" machines, and the "Air Ball" Governor standard on the larger.

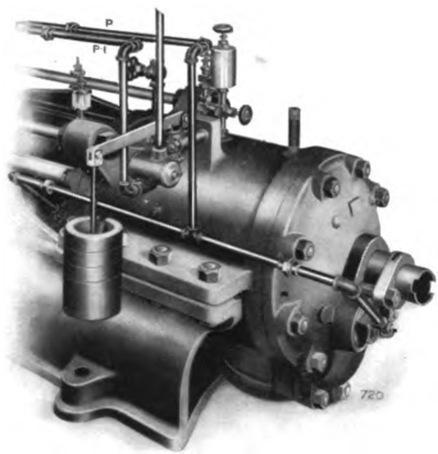


The "A-14" Steam Regulator

For such conditions as air lift pumping, where any constant speed with a variable pressure is required, a "Variable Speed" Governor can be supplied on all sizes, at extra cost.

The Air Unloader and Steam Regulator

The "A-14" Steam Regulator consists of a valve in the steam



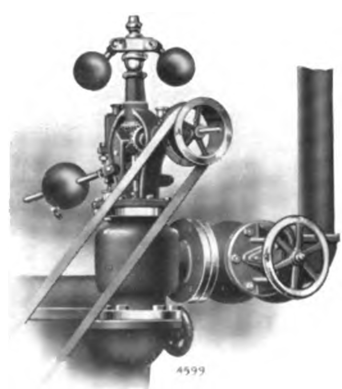
The "A-28" Air Unloader

supply, inside the throttle, operated against a spring by air pressure from the receiver. Under normal running conditions this valve is fully open. When pressure rises above normal, air pressure closes the steam valve, cutting down the speed of the machine to a point where it simply turns over. The extent to which the steam regulator valve closes is controlled by an adjusting nut.

The "A-28" Air Unloader consists of a weighted lever and air pressure cylinder operating under excess air pressure to open and hold open one or more of the discharge valves. This, of course, closes the intake valves and the piston moves under balanced pressures, the machine being completely unloaded. Simultaneously the steam regulator valve operates to cut down speed. This device can be set to operate at any desired maximum pressure by adjusting the weight on the regulator.

The "Air Ball" Governor

The "Air Ball" Governor combines the functions of an adjustable limit speed governor and an air pressure regulator. It is driven by an outside belt from a return crank, being thus protected from oil from the main bearings. The speed-governing element consists of the usual fly-ball arrangement, throttling the steam when speed



The Standard "Air Ball" Governor

exceeds a fixed limit. The pressure-regulating element consists of an air-operated piston working in connection with the speed governor to control the speed of the compressor between maximum and minimum, maintaining air pressure within a few pounds of normal under all loads within the range of speeds.

The "Variable Speed" Governor

The "Variable Speed" Governor

The "Variable Speed" Governor is another fly-ball device which can be adjusted to maintain a constant speed and output under changing operating conditions, as in Air Lift work. It is belt driven from an outside pulley and can be adjusted for any desired speed.

Air Intake Connections

The admission of cool, clean air to an air compressor has an important effect on its economy and life. The "Hurricane-Inlet" valve makes it particularly convenient to admit air from a suitable source, preferably from outside the engine room and from an elevated position out of the way of dust. A very common, but not altogether satisfactory, method is that of building a wooden box around the inlet tube of the machine. This is at best but an unsightly makeshift, and it is very difficult to keep it dust-tight. The Ingersoll-Rand Company therefore offers two intake connections consistent in workmanship and appearance with the compressor itself. These are furnished only on order and at extra cost.

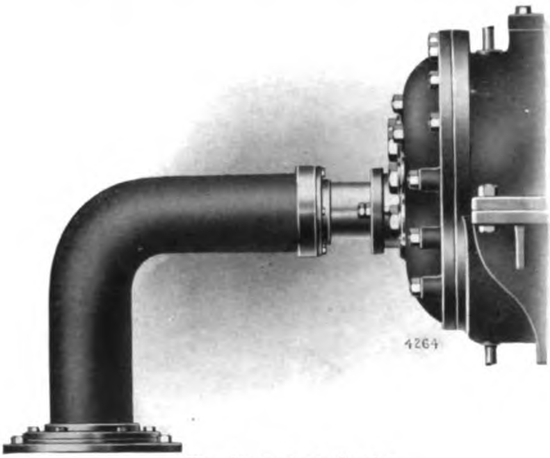
The Atmospheric Intake

This consists of a horizontal pipe surrounding the inlet tube

and terminating in a brass collar which just clears the tube. It gives in effect an air-tight connection but avoids any friction at this point. This is intended only for handling free air.

Intake Extension Bracket

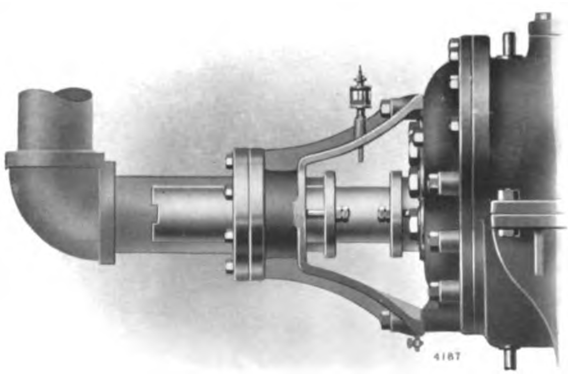
The second type of intake connection offered is designed for use with air or gas under pressure or for a vacuum. The bracket has a single stuffing box around the inlet tube in addition to the stuffing box in the cylinder head. A companion flange is furnished on the bracket for pipe connections, but no piping is supplied.



The Atmospheric Intake

Sizes and Capacities

Standard sizes and capacities of Class "A-1" Compressors, with other important data, are given in the table on the following page. This pamphlet is not intended to go into the minute details of construction of these machines. This later information is set forth in the specifications which will be furnished to those asking for a quotation on a compressor to meet conditions as set forth in the request for information.



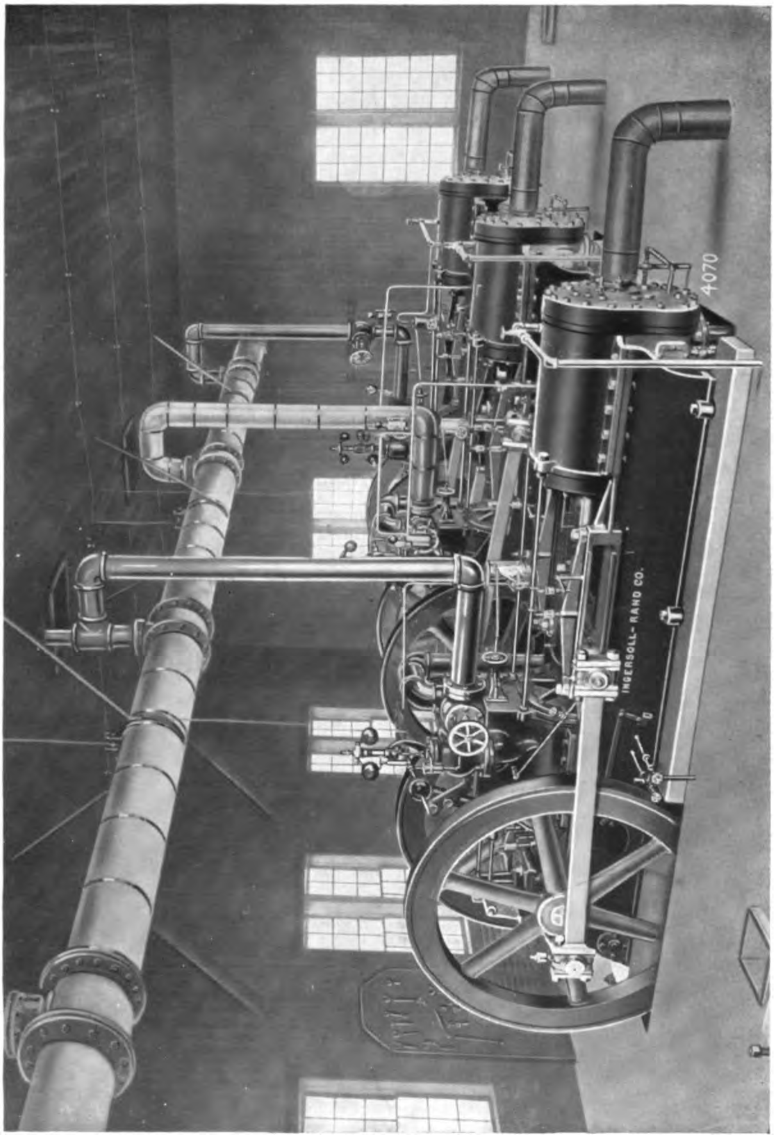
The Extension Bracket

Straight Line Steam Driven Air Compressors, Class "A-1"

Steam Pressure 80-120 Pounds

Telegraph Name	Cylinder Dimensions Inches			R. P. M	Piston Displacement Cubic Feet Per Minute	Air Pressure Designed for	I. H. P. in Steam Cylinder	Over All Dimensions Feet and Inches			
	Diameter		Stroke					Length Over All	Width Over All	Height Above Foundation	Length of Bed Plate
	Steam	Air									
Abbog	12	12¼	14	155	285	50-100	37- 57	12-5	3-9	3-4	9-5
Abcad	12	14¼	14	155	383	30- 80	36- 68	12-7	3-9	3-4	9-5
Abcig	12	16¼	14	155	496	15- 35	29- 54	12-7	3-9	3-4	9-5
Abdeg	14	14¼	14	155	383	50-100	50- 76	12-7	3-9	3-4	9-5
Abduk	14	14¼	18	120	381	50-100	49- 74	15-2	4-3	4-3	11-8
Abeck	14	16¼	18	120	489	40- 85	56- 89	15-2	4-3	4-3	11-8
Abeks	14	18¼	18	120	628	25- 50	52- 83	15-3	4-3	4-3	11-8
Abelt	14	20¼	18	120	770	15- 35	44- 83	15-3	4-3	4-3	11-8
Abery	14	22¼	18	120	924	10- 25	39- 80	16-0	4-3	4-3	11-8
Abfag	16	16¼	18	120	489	50-100	64- 97	15-2	4-3	4-3	11-8
Abfok	16	18¼	18	120	628	40- 80	71-110	15-3	4-3	4-3	11-8
Abful	16	20¼	18	120	770	25- 50	64-103	15-7½	4-3	4-3	11-8
Abgum	16	22¼	18	120	924	15- 35	53- 99	16-0	4-3	4-3	11-8
Abhun	*18	18¼	18	120	628	40- 80	75-116	15-3	4-3	4-3	11-8
Abikt	18	18¼	24	94	656	50-100	83-126	19-0	5-3	5-3	14-7
Abipy	18	20¼	24	94	807	40- 90	91-149	19-0	5-3	5-3	14-7
Abjim	18	22¼	24	94	973	25- 50	80-129	19-0	5-3	5-3	14-7
Abjon	18	24¼	24	94	1150	15- 40	66-135	19-0	5-3	5-3	14-7
Abkal	18	26¼	24	94	1345	10- 30	57-132	19-0	5-3	5-3	14-7
Abkur	20	20¼	24	94	807	50-100	102-155	19-0	5-3	5-3	14-7
Ablam	20	22¼	24	94	973	40- 85	110-174	19-0	5-3	5-3	14-7
Ablip	20	24¼	24	94	1150	25- 50	96-154	19-0	5-3	5-3	14-7
Abman	20	26¼	24	94	1345	10- 40	58-165	19-0	5-3	5-3	14-7
Abmir	22	22¼	24	94	973	50-100	124-187	19-0	5-6	5-3	14-7
Abmut	22	24¼	24	94	1150	40- 80	129-203	19-0	5-6	5-3	14-7
Abnap	22	26¼	24	94	1345	30- 50	129-122	19-0	5-6	5-3	14-7
Abnot	*24	24¼	24	94	1150	40- 80	126-201	19-0	5-6	5-3	14-7

*Designed for Steam pressure of 50-70 lbs.

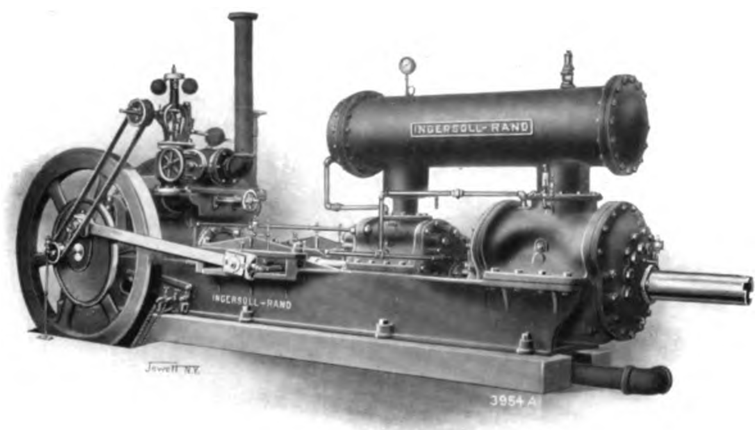


Three Class "A-1" Compressors at the Helvetia Shaft of the Rochester and Pittsburg Coal Co.

CLASS "AA-2"
STRAIGHT LINE STEAM DRIVEN TWO-STAGE AIR COMPRESSORS

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

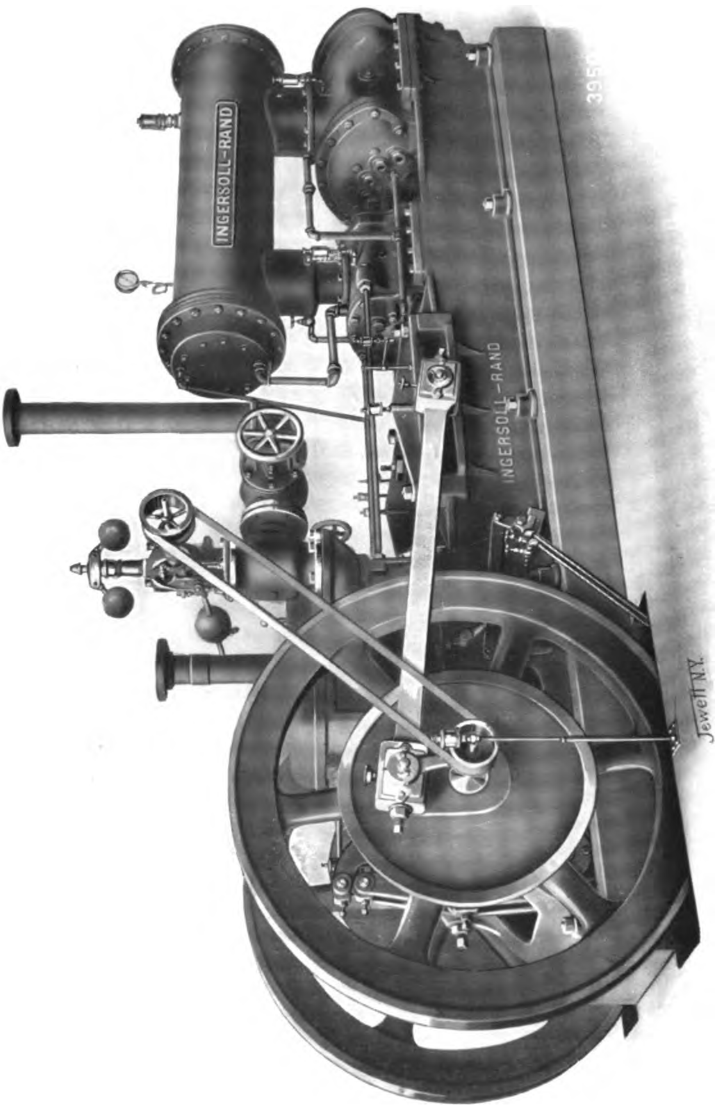
Form No. 3003 September, 1910



View from the Air End of the Class "AA-2" Air Compressor

THE straight line air compressor finds its typical example in the Class "A-1" steam driven single stage machine, which is fully described in Pamphlet 3002. The field for this simple machine is that broad class of mining, contracting, quarrying and industrial work, where compressed air is economically desirable or essential, yet where the question of high operating economy is second to simplicity and to the ability to stand hard, "knock-about" service.

At the other extreme are those large permanent plants where every refinement looking to high economy in the production of compressed air is sought and where skilled attendance worthy of a high-duty machine is to be counted upon. This is obviously the proper field for the duplex compressor with its compounded steam



View from the Steam End of the Class "AA-2" Compressor

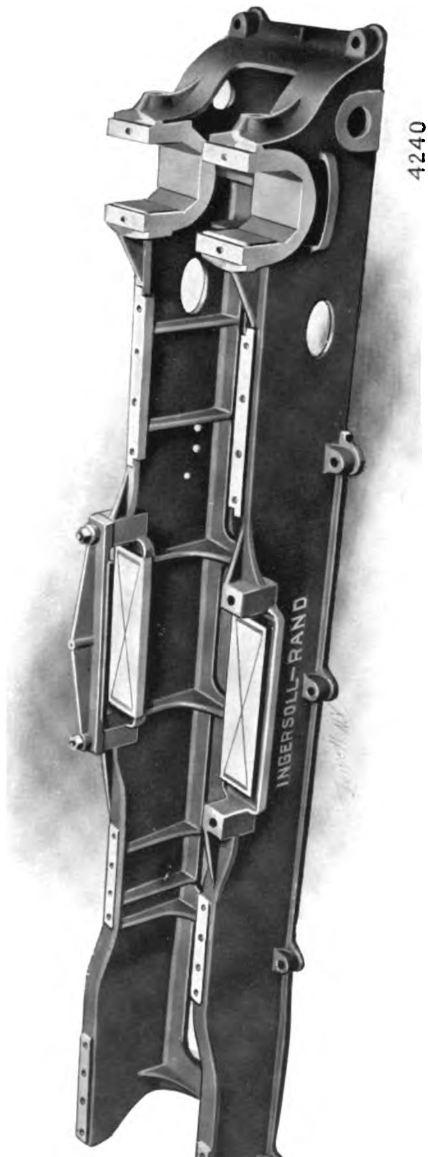
cylinders, its two-stage air cylinders, and its other economical refinements. In such instances the higher first cost of the duplex compressor as compared with the straight line type is fully justified by the permanence of the installation and by the higher operating economy which follows.

Between these two fields lies a middle ground where compressed air is wanted, where simplicity and ease of management are essential, and where a high, but not the highest economy, is desirable. This middle ground is the field for the simple steam two-stage straight line machine, which finds its highest type in the Ingersoll-Rand Class "AA-2" Compressor, which is the subject of this pamphlet.

From this machine may be expected: the simplicity, compactness and self-contained qualities of the straight line type; the economy in compression afforded by the best two stage design, fully up to the duplex standard; and a mechanical efficiency, an "all-around" economy, and a reliability measuring up to all practical requirements. The price, too, affords a compromise between the less expensive and less economical single stage straight line and the more costly but more efficient duplex.

The General Design

Straight line directness is the first quality of the Class "AA-2." Thrust and pull in the steam cylinder are directly applied to resistance in the air end, without the intervention of power-consuming mechanism. The continuous bed-plate supports all parts of the machine, combining the structure into a solid unit. Twin outside-connected fly-wheels are at one end. Next to them is the simple steam cylinder. In the middle are the crosshead and crosshead guides. At the other end are the air cylinders, with a longitudinal over-head intercooler. The low pressure air cylinder is at the extremity of the machine for convenience in arranging the air intake connections. Generous bearing surfaces, proper use of anti-friction metals, heavy and rigid construction, and ample lubrication combine to reduce the friction load to the practical limit. In the simple steam cylinder the best cut-off steam economy is realized; in the two-stage air end the full advantage of compound compression is obtained.



The Main Frame or Bed-Plate of Class "AA-2" Compressors,
Showing Internal Strengthening Ribs and the Well Braced Main Bearings

Simplicity

The entire absence of cumbersome and complicated valve gearing is a conspicuous feature of the Class "AA-2." The new single-eccentric steam valve gear greatly simplifies construction at this point. The air valves are positive and automatic, free from any mechanically driven devices, and requiring no setting or adjusting. An examination of this machine in detail will show the care with which every possible trouble-making element has been removed. The "AA-2" comes as near the ideal of "taking care of itself" as a large, heavy-duty, high-duty machine can.

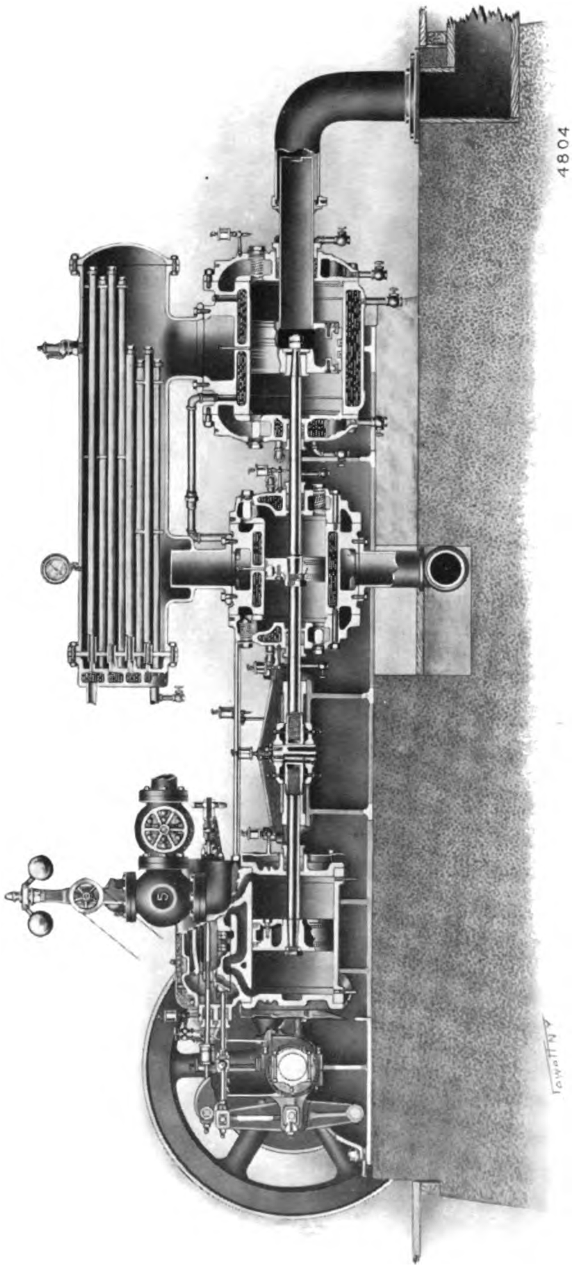
Accessibility

The "AA-2" Compressor has an accessibility inviting the careful attention which its high-duty characteristics deserve. The main bearings are at one end of the main frame, the pedestals being a part of the frame castings. These bearings, with the rocker arms and eccentric strap, are readily accessible between the fly wheels and can be inspected while running. Fly-wheels, shaft and crank can be removed or replaced by simply raising a few inches and rolling out or in. This operation does not require that the shaft shall clear the steam cylinder at one end or the air cylinders at the other, nor is it necessary to disconnect any piping or take down any air valve gear.

The steam piston may be removed at the crosshead end of the cylinder without interfering with the steam valve gear. Cross-head and guides are open to inspection on both sides. The high pressure air piston can be taken out at the end next to the cross-head. The low pressure piston can be removed by taking off the outer cylinder head. The entire nest of tubes can be removed bodily from the intercooler at the end toward the steam cylinder.

A Unit Construction

The "AA-2" Compressor is distinctly a unit—strong, rigid and self-contained. The box bed-plate, heavily ribbed and reinforced, not only supports the structure from end to end but distributes the weight uniformly over the foundation and requires a foundation of the simplest character. This unit quality is an important consideration where the machine can be transported complete. But for difficult roads and trails the type lends itself readily to a



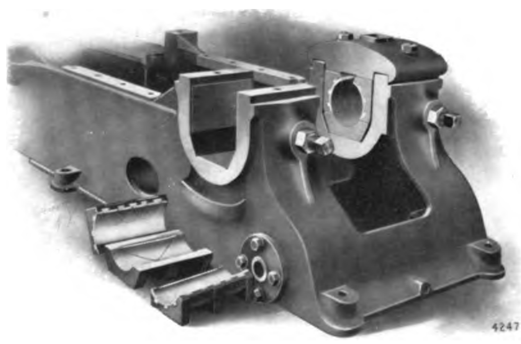
Longitudinal Section of Class "AA-2" Compressor, illustrating the Straight Line Principle

"knock-down" process into parts handled with comparative ease. The rugged strength of this machine is a guarantee of its stand-up qualities. The system of absolute interchangeability under which it is built makes the stock of duplicate parts carried by the Company at factory and sales branches a further guarantee against undue delays should an accident occur. Any average mechanic can replace a broken part with a new one in machines of this class.

The Straight Line Principle

A fine point in the mechanical design of these compressors is that the steam and air cylinders meet the bed-plate in a plane with the center line of all the cylinder bores. This obviates any tendency to buckle the frame or lift the cylinders under the stresses of compression.

Cylinders and bed-plate are held together by fitted bolts driven into holes bored and reamed at one setting by means of an accurate metal template. This positively forbids any loss of alignment and even after the machine has been dismantled it can be put together with a certainty that all parts are in line.

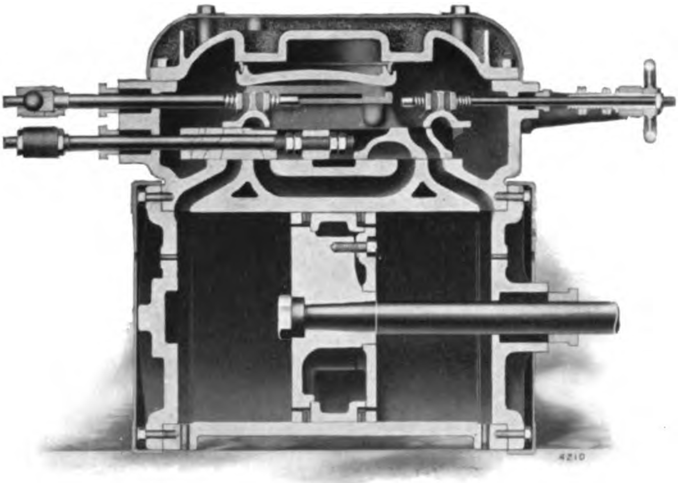


The Main Bearings of "AA-2" Compressors

The Steam End

The steam cylinder of Class "AA-2" Compressors represents the best modern simple steam engine practice, giving all the economy possible with the improved balanced adjustable cut-off valves which distinguish these machines.

In the design of the steam end the limitations of the straight line type have been carefully considered; and it has been deemed better to give the purchaser of the "AA-2" machine the assured economy of the standard adjustable cut-off valve than to furnish him a Corliss steam valve movement of theoretically higher efficiency, but with a more complicated and delicate valve gear



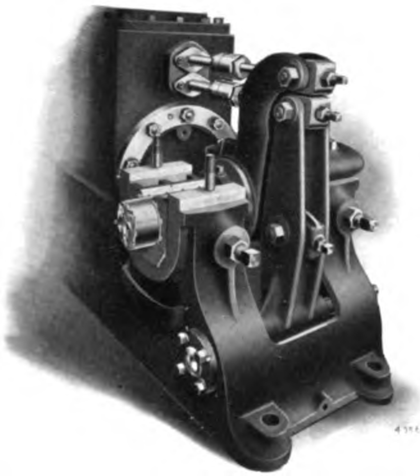
Longitudinal Section of the Steam Cylinder of the Class "AA-2" Compressor, showing the Balanced Adjustable Cut-off Steam Valves and Large Ports and Passages

which might prove to be a positive detriment rather than an advantage.

For much the same reasons it has not been considered advisable to compound the steam ends of Class "AA-2" Compressors in standard types. Compound steam expansion depends for its economy on the maintenance of proper ratios of expansion. While these proper ratios can be maintained where the load is constant and the cut-off unchanged, yet any attempt to vary speed and output by a change in cut-off destroys these proper ratios. It is, of course, possible to regulate the compound steam compressor by a throttling governor without destroying the expansion ratios. This is, indeed, the method usually used on duplex cross-compound Meyer valve steam compressors. But there is this vital difference between the compound steam straight line and the compound steam duplex. In the compound duplex, the angular arrangement of the cranks permits one cylinder to help out the other, and maintains good operating conditions even at the slowest speeds. In the tandem compound, however, at slow speeds, there is not power enough with a short cut-off to keep the machine running; and if the cut-off is lengthened to operate at slow speeds the ratios of expansion are destroyed and the economy sacrificed. "Double tandem compound" compressors

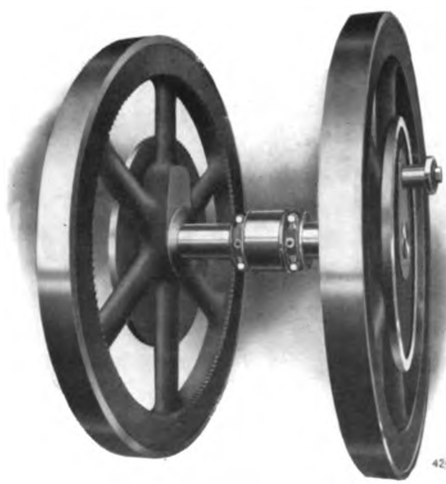
cannot be considered economically self-regulating at less than 60% of full load.

The design of the valve chests and ports in "AA-2" Compressors gives unusually large port areas, direct steam passages and a minimum of clearance. The valve chest and the walls of the cylinder are lagged with a non-conducting material and sheathed with a steel casing. The cylinder heads have a cast iron cover.



End View showing Rocker Arms and Single Eccentric Valve Gear

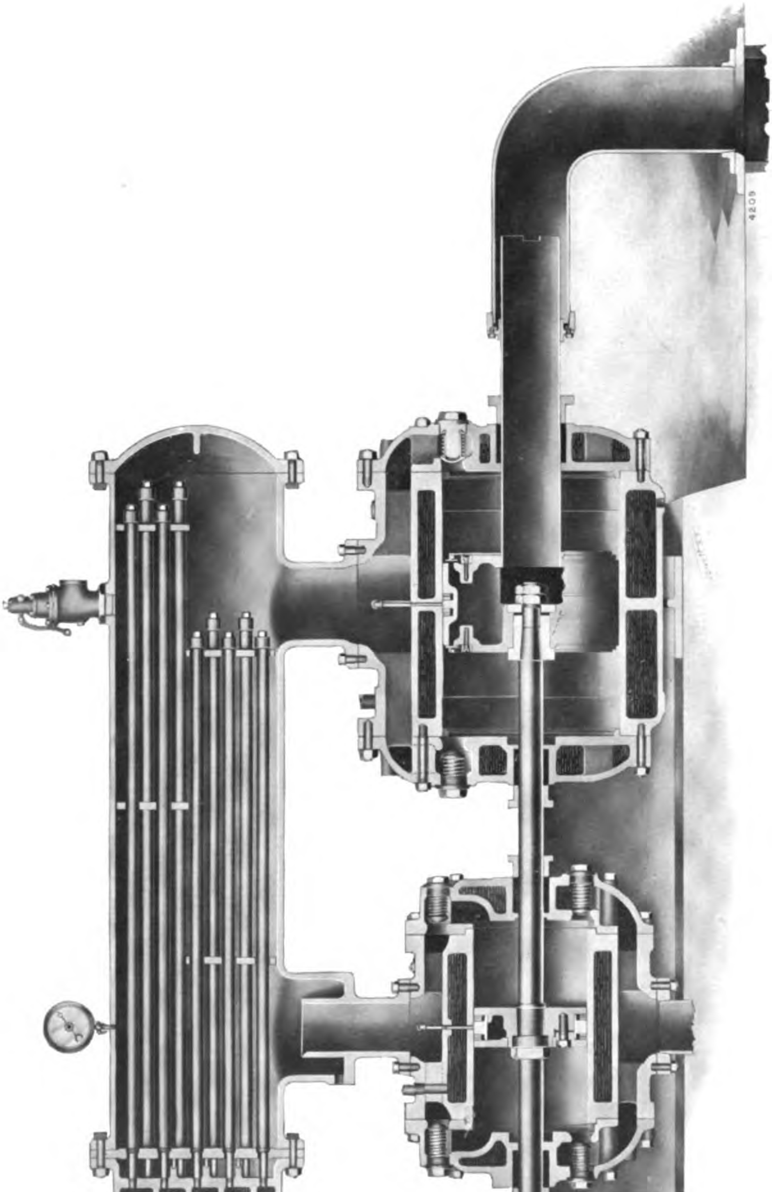
The steam valves are an improved balanced Meyer adjustable cut-off type, with friction and power consumption in the valve gear reduced to the minimum. A single eccentric is used, giving an independent movement by means of two rocker arms to the main and cut-off valves. This construction not only permits making the main bearings longer, but also centers the stresses on the rocker arms, so that breakage of these parts is almost unknown.



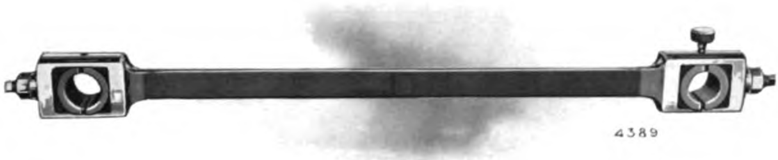
The Flywheels and Shaft showing the Single Eccentric and Oil Disk on the Wheels

The Oil Gathering System

The drip or overflow from all lubricated surfaces is collected in a basin in the bedplate. For this purpose a lip is provided



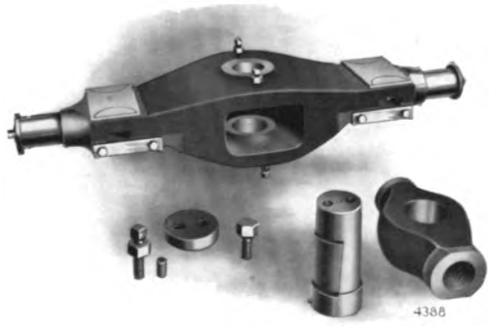
Longitudinal Section Through Air Cylinders and Intercooler of the Class "AA-2" Compressor, showing the Ample Air Passages and Large Intercooler



The Solid End Connecting Rod of "AA-2" Compressors

around the crosshead guides and beneath the main bearings on the outside. Double oil rings on the eccentric and on the inside hubs of the flywheels prevent the escape of oil at these points. A disk on the flywheel with a rim around it collects any oil which may work out around the crank pin and this oil can be wiped out with a piece of waste when the machine comes to rest. As a result of these precautions the "AA-2" machine is exceptionally cleanly and no oil can run down to the foundation.

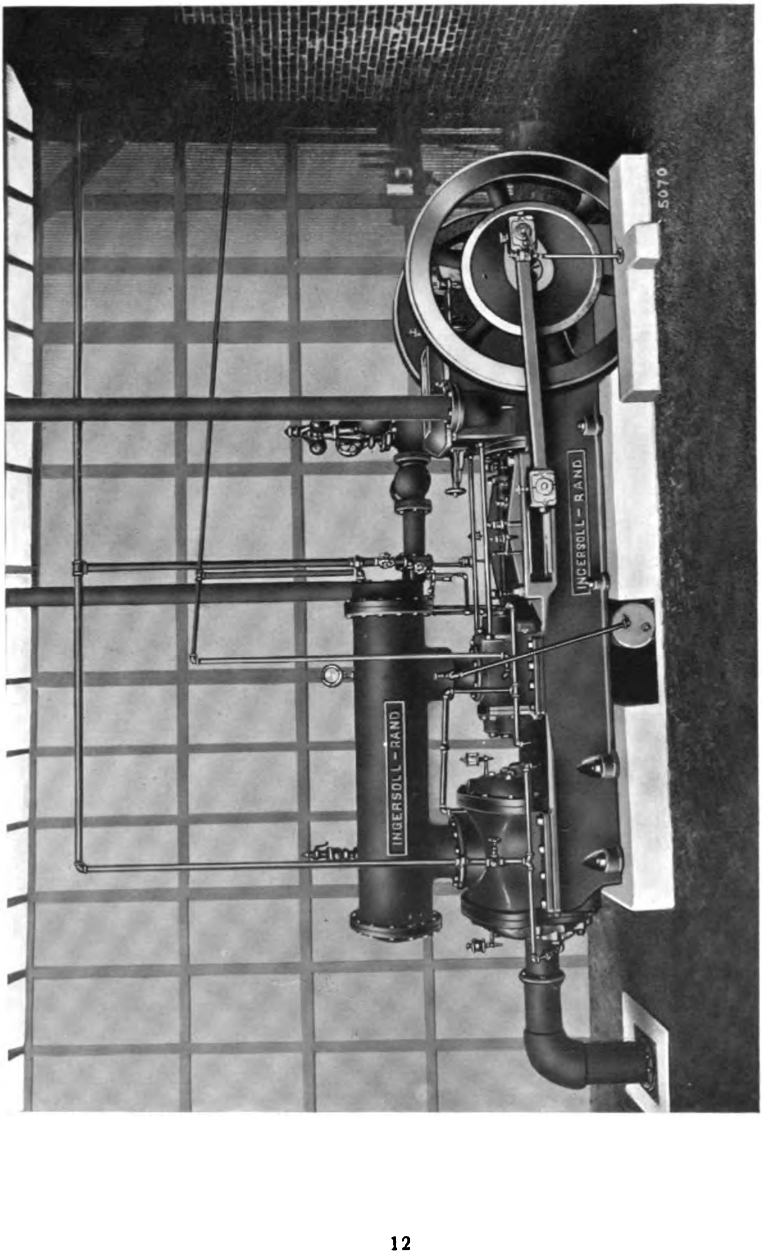
The Air End



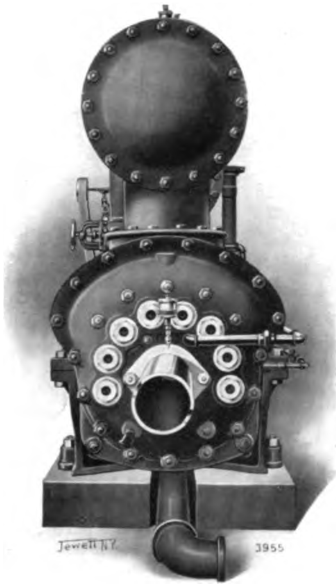
The "AA-2" Crosshead, with the Improved Adjustable Swivel Block Pin

High and low pressure air cylinders are cast with the shell and bore solid, the latter providing for two ordinary reborings. The cylinder heads as well as the barrel are jacketed. The distinguishing characteristics of this air end are: its unusually large, direct ports and air passages; the small clearance spaces; the complete water jacketing; and the simplicity of design.

The intercooler is of horizontal iron-body type, with the entire nest of tubes removable. Tube plates are of steel and tubes of galvanized iron. As all the tubes are free at one end there can be no trouble from expansion and contraction. The size of the intercooler shell is properly proportioned to give the



Class "AA-2" Compressor at the Plant of the Wilson & White Coal Co., Boonville, Ind.



End View of the Air Cylinder showing large Inlet Area and Discharge Passages

correct air velocity and a receiver capacity suitable for filling the high pressure cylinder. A water trap is provided around the discharge opening of the intercooler in which condensed moisture collects and from which this water may be withdrawn through a drain.

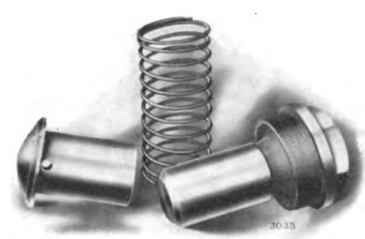
The low pressure air valves are of standard "Hurricane-Inlet" type. High and low pressure discharge valves and high pressure inlet valves are of "Cushioned Direct Lift" type. As all of these valves are described in detail in Pamphlet 3001, sent on request, further details are here omitted.

It is to be noted that the inlet and discharge valves of the high pressure cylinder are identical and interchangeable, making a small stock of reserve valves ample for emergency in either case.

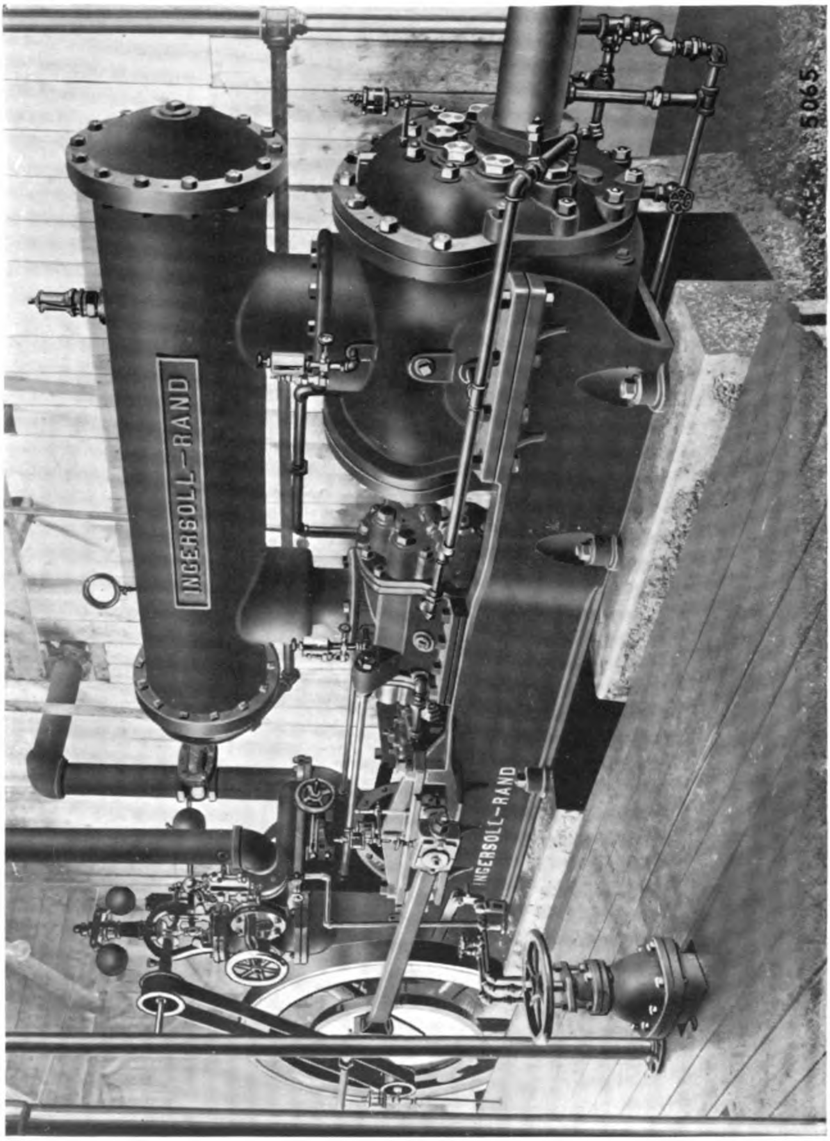
This combination of "Hurricane-Inlet" and "Cushioned Direct Lift" discharge valves admits and discharges more air for a given cylinder displacement than any other valve types under the operating conditions for which Class "AA-2" Compressors are intended.

Regulation

The standard regulator on all sizes of Class "AA-2" Compressors is the "Air Ball" Governor, which is always furnished unless otherwise specified. For special conditions and when designated on order, any of these machines may be fitted with the "A-29" Air



The Three Parts of a "Cushioned Direct Lift" Discharge Valve

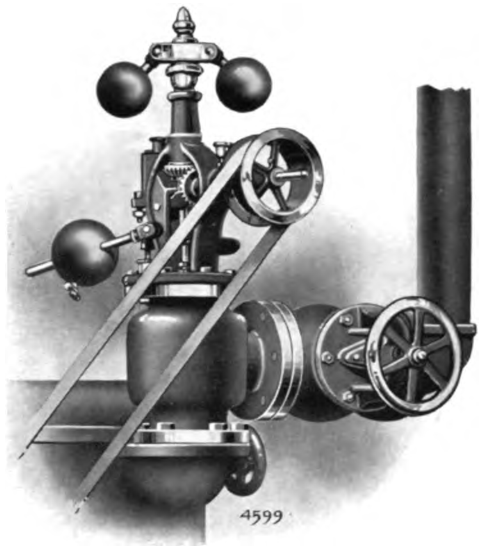


One of two Class "AA-2" Compressors at the Plant of Rinehart & Coleman, Pleasantville, N. Y.; being used on the Catskill Aqueduct

Unloader and the "A-14" Steam Regulator, or with a "Variable Speed" Governor.

The "Air Ball" Governor

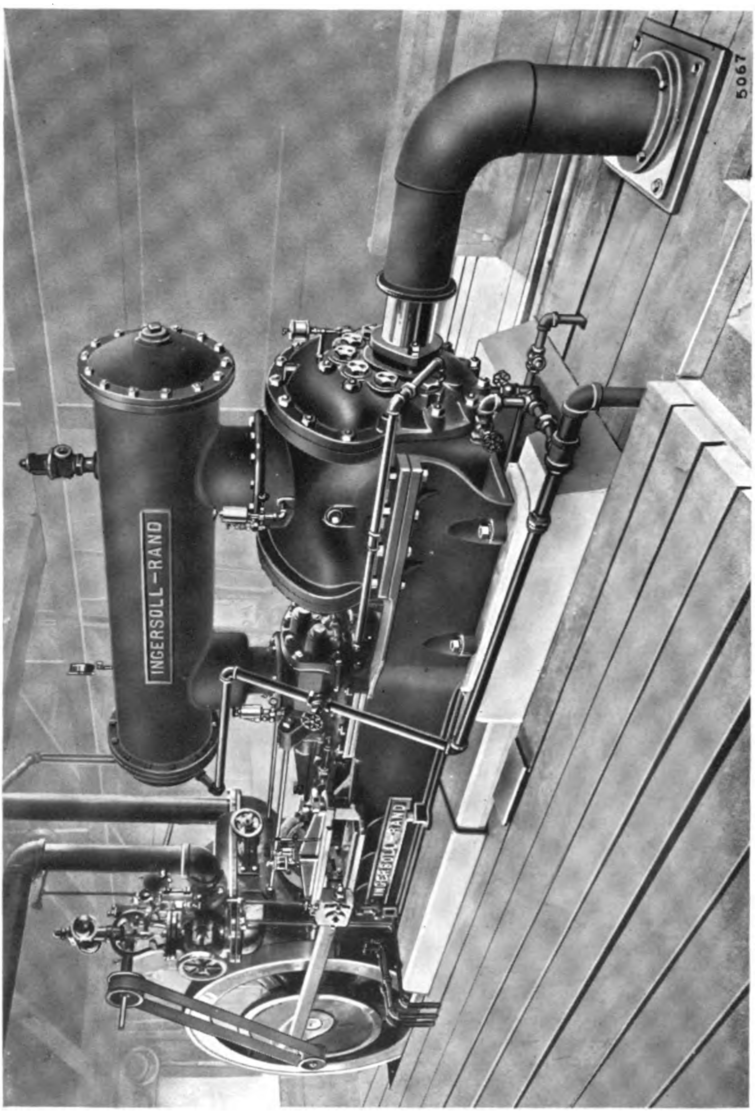
This device combines the functions of an adjustable limit speed governor and an air pressure regulator. The governor is driven by an outside belt from a return crank, being thus protected from oil from the main bearings. The speed-governing element consists of the usual fly-ball arrangement throttling the steam when speed exceeds a fixed limit. The pressure regulating element consists of an air-operated piston working in connection with the speed governor to control the speed of the compressor between maximum and minimum, maintaining the air pressure within a few pounds of normal under all loads within the range of speeds.



The "Air Ball" Governor

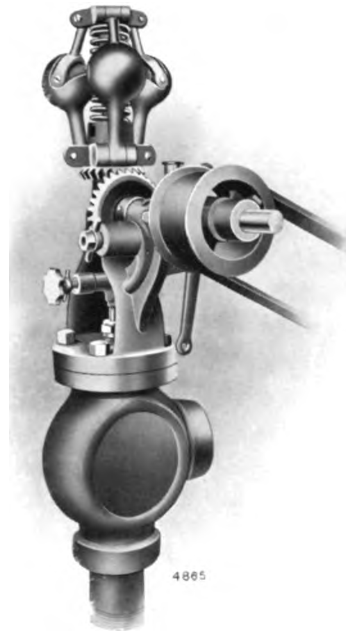
The Air Unloader and Steam Regulator

The "A-29" Air Unloader consists of a weighted lever and air pressure cylinder operating under excess air pressure above normal to open and hold open one or more of the discharge valves at each end of both air cylinders. This admits receiver pressure to the cylinders, closing the inlet valves; and the pistons then move under balanced pressures. Simultaneously the steam regulator valve operates. This device can be set to operate at any desired maximum pressure by adjusting the weight on the lever.



One of two Class "AA-2" Compressors at the Plant of Rinehart & Dennis, Kensico Cemetery, N.Y.; at work on the Catskill Aqueduct

The "A-14" Steam Regulator consists of a valve in the steam supply opened against a spring by air pressure from the receiver. Under normal running conditions this valve is fully open. When air pressure rises above normal, this pressure is exhausted, closing the steam valve and cutting down the speed of the machine to a point where it simply turns over. The extent to which the steam regulator valve closes is controlled by an adjusting nut.



The "Variable Speed" Governor

The "Variable Speed" Governor

There are certain operating conditions, such as Air Lift pumping, where it is necessary to maintain a constant speed and output even under a varying pressure. The"VariableSpeed" Governor is furnished for such conditions. It is a fly-ball device, belt driven from an outside pulley, which can be adjusted to maintain any desired speed under changing load. This is a standard device entirely adequate under the conditions for which it is intended.

Air Intake Connections

The admission of cool, clean air to an air compressor has an important effect on its economy and life. The "Hurricane-Inlet" valve makes it particularly convenient to admit air from a suitable source, preferably from outside the engine room and from an elevated position free from dust. The Ingersoll-Rand Company offers two intake connections consistent in workmanship and appearance with the compressor itself.

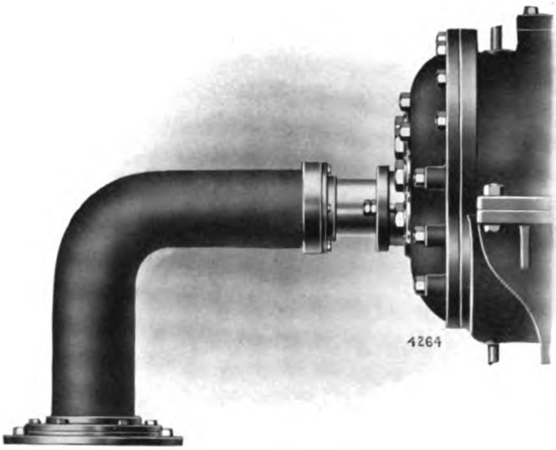
The Atmospheric Intake

This is a part of the standard equipment of the "AA-2" Compressor and will be furnished unless otherwise ordered. The

horizontal pipe surrounds the inlet tube and is closed with a brass connection but with no added friction.

The Extension Bracket

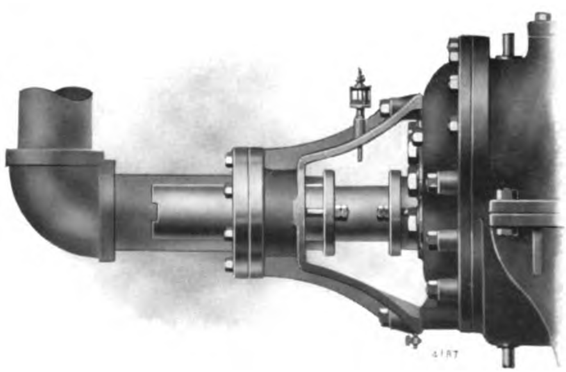
The second type of air intake is designed for use with air or gas under pressure or for a vacuum. The bracket is provided with a single stuffing box around the inlet tube. No piping is furnished but a companion flange is attached to the bracket. This connection is special, but will be substituted for the Atmospheric Intake at no extra cost if specified in the order.



Standard Atmospheric Intake

Sizes and Capacities

Six standard sizes of the Class "AA-2" Compressor are offered. These are listed, with related data, in the table on the following page. It will be noted that special steam cylinders can be furnished for low steam pressure.



Special Extension Bracket

Detailed specifications illustrating and describing the fine points of construction of these machines will be furnished on request.

Straight Line Steam Driven Two Stage Air Compressors, Class "AA-2"

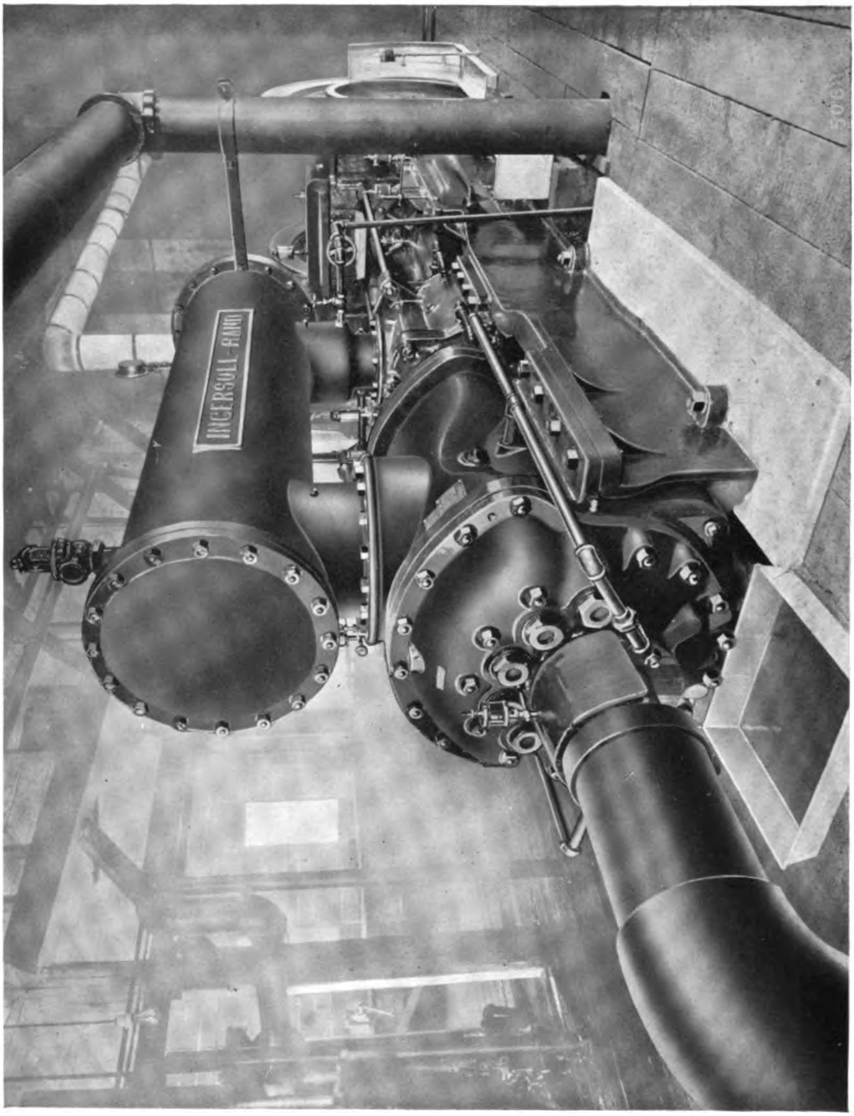
Steam Pressure 80-150 lbs. Sea Level

Telegraph Name	Cylinder Dimensions, Inches: Diameter, Steam	Diameter, L. P. Air	Diameter, H. P. Air	Stroke, Inches	R. P. M.	Piston Displacement Cubic Feet Per Minute	I. H. P. in Steam Cylinder at Air Pressure Given, Sea Level, 90 Lbs.	Sea Level, 110 Lbs.	Overall Dimensions, Feet and Inches: Length	Width	Height
Avjox	14	16¼	10¼	14	**220**	**690**	118	131	18–0¾	4–0	5–9
Avnel	16	18¼	12¼	16	**200**	**879**	148	165	19–7	4–3	6–3
Avpem	18	20¼	13¼	18	**180**	**1115**	186	206	21–1¼	4–6	6–9
Avria	20	22¼	14¼	21	**160**	**1390**	229	254	24–0	5–0	7–9
Avyoa	22	24¼	15¼	24	**140**	**1644**	271	300	26–3½	5–6	8–0
Avzin	24	27¼	16¼	27	**130**	**2178**	355	394	28–8¼	6–0	8-3

Special Steam Cylinders for 60-80 lbs. Steam Pressure

Stroke Inches	Equivalent Low Pressure Steam Cylinder: Telegraph Name	Diam., Inches	Stroke Inches	Equivalent Low Pressure Steam Cylinder: Telegraph Name	Diam., Inches	Stroke Inches	Equivalent Low Pressure Steam Cylinder: Telegraph Name	Diam., Inches
14	Seyth*	16	18	Sfarz*	20	24	Sfend*	24
16	Sfalc*	18	21	Sfecc*	22	27	Sferr*	26

* These code words to be suffixed to code words for complete machine to specify compressor with low pressure steam cylinder.



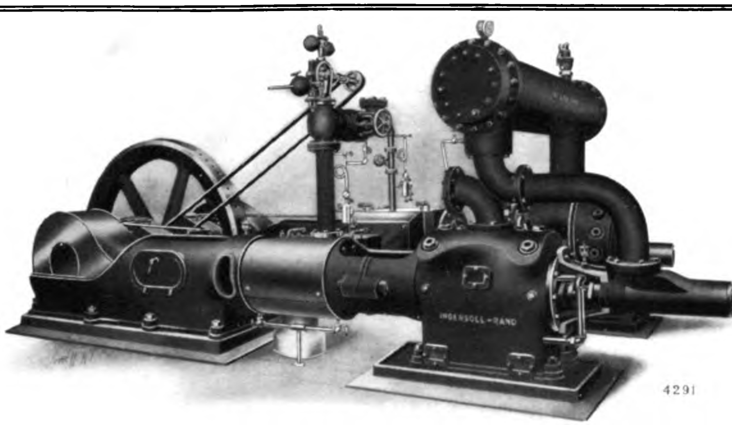
Class "AA-2" Compressor at the Plant of Henry Steers, Inc., on the New York, Boston and Westchester R. R.

CLASS "O"
DUPLEX STEAM DRIVEN AIR COMPRESSORS

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Form No. 3006 December, 1909

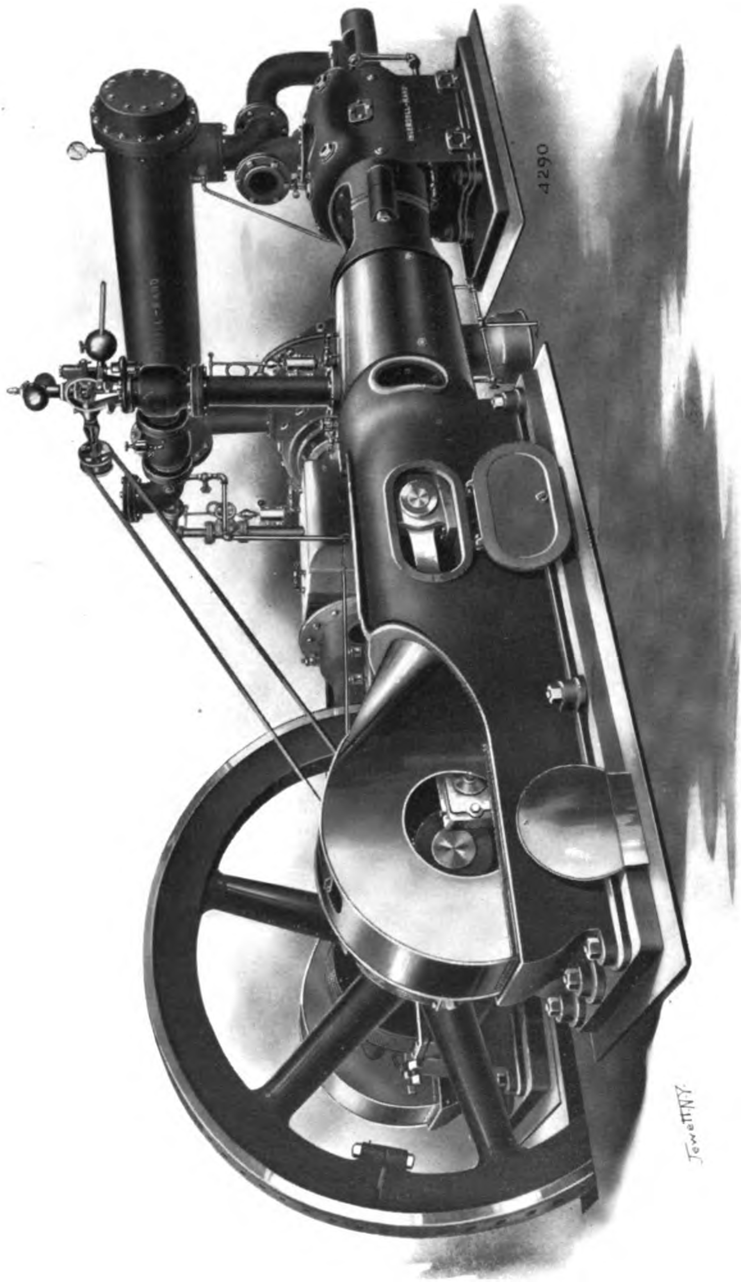


Class "O-3" Steam Driven Air Compressor

A PERIOD of about forty years covers practically the entire history of the development of compressed air as a power; while only the past decade may be said to have witnessed the attainment of the commercial importance which compressed air merits. These last ten years have been wonderfully fruitful of improvements in pneumatic practice. But the trend of this development has been rather in the direction of improvements in details than in the development of entirely new machines.

Particularly is this found to be true when the air compressor — the fundamental basis of any compressed air system — is studied. New valve movements and valve designs, improved cooling devices, advances along the line of mechanical design, have brought the modern air compressor to a degree of economy and reliability hardly dreamed of fifteen or twenty years ago.

It has remained for the Ingersoll-Rand Company, the pioneer compressor builders of the world, to produce the first air compressors in which all of the latest improvements have been combined in a machine of distinctly modern design. In the straight line type, the Ingersoll Class "AA" steam driven, and the Class "BB" power driven,



Standard Class "O-3" Steam Driven Air or Gas Compressor, with Cross-Compound Steam and Two Stage Compressing Cylinders with Intercooler

are such machines. In the duplex type the Class "PE" direct-connected electric, and the Class "PB" belt or rope drive, have established new standards of power driven construction. These four types are covered by separate pamphlets.

The present pamphlet is devoted to the Class "O" steam driven compressor, which marks an advanced position in machines of this class which has never hitherto been reached. The Class "O" proper, the subject of this pamphlet, has balanced Meyer adjustable steam valves. The fundamental "O" type, however, has been developed into the Class "OC" compressor, to which a separate pamphlet (No. 3023) will be devoted and which differs from the "O" machine only in having Corliss steam cylinders, thus affording all the advantages of the "O" design in combination with the still higher steam economy of the Corliss steam end.

General Type

The page illustration opposite gives a more clear idea of the Class "O" compressor than any description can convey. It is of the familiar duplex type, its two halves, except in the largest size, being joined by a heavy trunk extension between the main frames. The steam cylinders are next to the frames and separated from the air cylinders by open distance pieces.

In compound steam types the steam receiver is below the floor and set transversely. In compound air types the intercooler is transverse and above the cylinders. Frames are fully enclosed and a flood lubrication system is provided. Sole plates are placed under both air cylinders. The distinctive features of the Class "O" design are its massive, powerful construction and its simplicity. It is marked by a rugged strength, ample reserve power, and unlimited capacity for hard work.

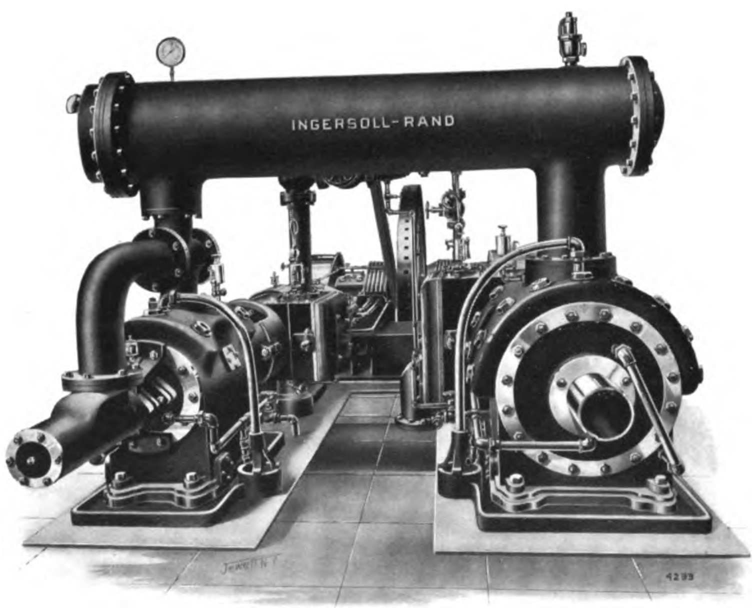
Simplicity

As compared with the straight line type, the duplex compressor has generally, and wrongly, been considered a rather complex machine, to be used only where constant attention and the best of skilled attendance could be given it. The design of the Class "O" compressor, however, is marked by a simplicity fairly comparable with that of the "old reliable" straight line. It is a duplex compressor divested of all possible trouble-making elements, with inlet and discharge valves automatic at all speeds

and pressures, requiring no setting or adjusting. It can be entrusted with the most arduous duty without fear of a breakdown or rapid loss of efficiency.

Automatic Features

Second in importance only to simplicity, as related to operating conditions in the modern power plant, is the question of automatic action — the faculty for doing the requisite amount of work with the least possible attention under all load conditions. Class "O" compressors are as completely automatic in action as it is possible to make a high-grade compressor. The "personal equation" of the attendant must always enter in some degree into the operation of a high-duty machine; but in this new type this element has been reduced to the practical limit. Automatic control of speed and pressure, and regulation of output to load, are provided by the "Air Ball Governor" with which these compressors are fitted. The lubrication system, fully described later, is almost infallible and proportions the oil supply to the speed. The air valves simply take care of themselves.



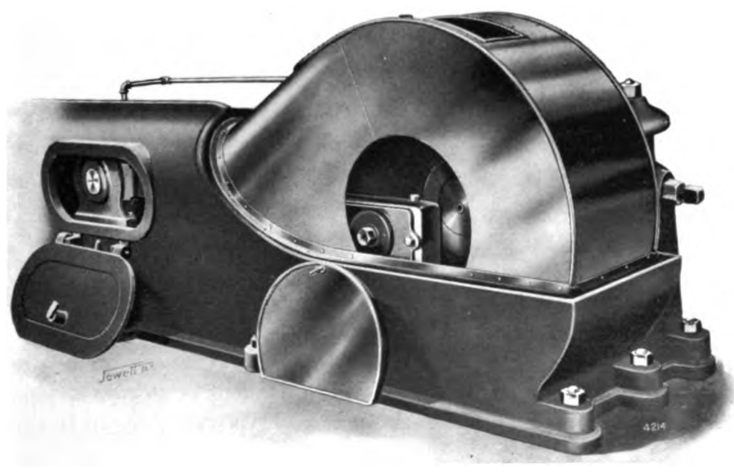
Air End View of Class "O" Compressor, Showing Trunk Extension between Frames and Illustrating the Accessibility of the Design

Accessibility

The floor plan of the Class "O" compressor is roughly a letter "H." The machine is accessible inside and out. At one end are the main bearings and the eccentrics, easily reached. On the sides are the cranks, crossheads, and connecting rods, accessible while the machine is in operation through the front and top doors on the oil guards and through the large door on the side of the main frame. At the other end are the air cylinders, accessible on three sides. In the middle are the steam valve gear and the throttle. The steam cylinders are open to inspection on both sides. Air pistons can be withdrawn at the back. Steam piston rods can be taken out at the front end. The telescope distance piece between steam and air cylinders, explained in detail later, permits examining the steam pistons or removing the steam piston rings without disturbing the alignment of the machine or moving heavy parts bolted to the foundation. The main bearing boxes can be removed or renewed without taking out the shaft.

Cleanliness

The enclosed construction over the cranks, around the crossheads, and surrounding the eccentrics, absolutely prevents the throwing of oil from these parts. Double-grooved oil rings on the shaft prevent the escape of oil at this point. An oil rim around the valve guides collects



Oil Guard over Crank of Class "O" Compressors, Showing Oil Doors in Guard and Frame, and the Enclosed Construction

oil and returns it to the crank basin. The sole plates beneath the air cylinders have rims preventing oil or water from running over the foundation.

Adaptability

The Class "O" type has been designed to readily admit of any combination of driving and compressing elements to meet operating conditions. Steam cylinders may be simple or compound, condensing or noncondensing, using saturated or superheated steam at any pressure. The air cylinders may be simple duplex or cross-compound two stage, adapted for a wide range of air pressures. There is almost no combination of requirements, except a demand for very high air pressures, which cannot be satisfied in standard machines of this class.

Ease of Installation

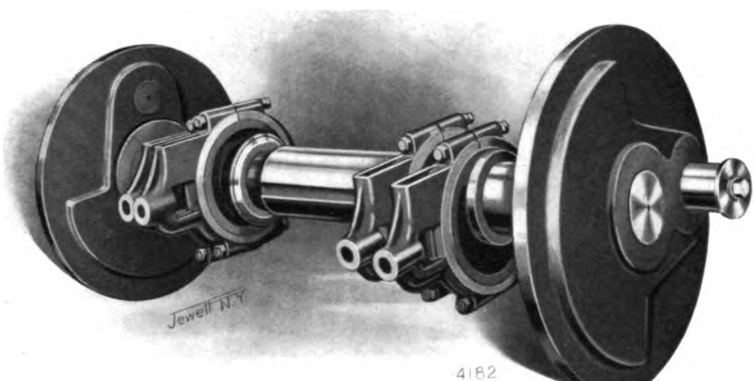
The Class "O" compressor has all the ease of installation which has hitherto characterized only machines of the bed-plate type. The trunk extension between the two main frames, used on all but the 27-inch stroke size, meets the latter parts on accurately planed surfaces and is securely bolted in place over heavy keys and dowels, so that its position must be absolutely correct. In effect this construction is equivalent to a solid "H" main frame. But it has not been considered necessary on the largest size of this type. Frames, cylinders, and distance pieces come together with a boss-and-counterbore joint. A surfaced joint is provided between the sole plates and the cylinder foot-pieces.

The shaft cannot be mounted out of line because planed surfaces on the main bearing boxes must coincide with planed surfaces in the main bearing jaws, the proper relative position of the latter being assured by the arrangement of the trunk extension. This latter arrangement also ensures parallelism between the center lines of the two halves of the compressor. Planed surfaces on frames and trunk extension serve as leveling strips in setting up the machine.

The foundation is of a type easily built, and the foundation bolts are so disposed as to be easily spaced in their correct relation in building the foundation, and readily accessible. While the Class "O" compressor is practically a solid unit when installed, yet it breaks up into parts handled with ease and convenience for transportation, for working in close quarters, for passing through restricted openings, or for placing on the foundation.

Duplex Characteristics

All of the recognized advantages of the duplex construction are embodied in Class "O" compressors: the balanced construction with quartered cranks, effecting an equalization of impulses and a mutual co-operation between the two halves of the compressor; the reduction of operating stresses by this balanced construction; the absence of any dead center, admitting of automatic and economical operation over the entire load range; the ease with which either or both steam and air cylinders can be compounded, securing the attendant compound economies without an increased number of parts. It has already been seen that, in addition to these advantages, the Class "O" possesses the solid, self-contained features of the straight line or of the bed-plate type of compressor. There can be no doubt that the duplex construction is the best for large, high-duty machines; and the Class "O" compressor reveals the duplex type at its very best.



Main Shaft, Cranks, Eccentrics, and Eccentric Straps of Class "O" Compressor

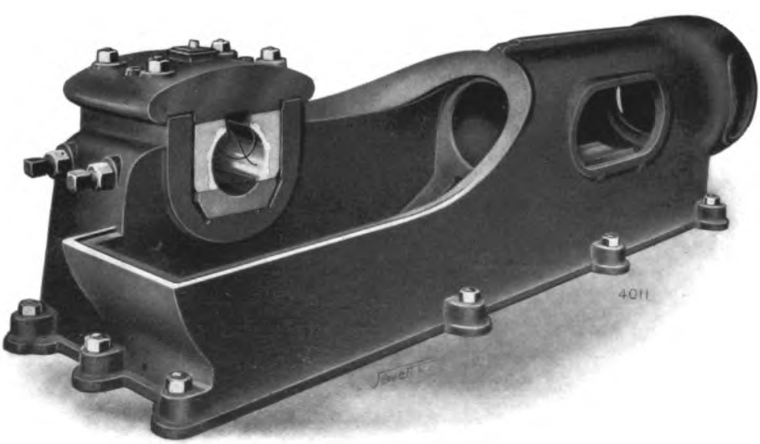
The Oiling System

The usual complement of high-grade sight-feed oilers, oil cups, lubricators, etc., is provided for the lubrication of steam and air cylinders, stuffing boxes, and steam valve gear. All other bearings, however, are supplied with oil by a "flood" system which this Company originated and developed to the only successful working basis. In the main frame is an oil basin with a quantity of oil into which the crank disks dip. In operation a small quantity of this oil is carried up on the

edge of the disks and caught at the top in a wiper which discharges it to a small pan or tank. Oil pipes lead from this pan to the main bearings, eccentrics, crank and crosshead pins, crosshead guides, and steam piston rods. Glass oil cups are set on the main bearings and on the crosshead guides through which the oil from the central system flows, thus showing the engineer at all times that the machine is getting an adequate supply of oil in these vital bearings. The flow of oil begins the moment the machine starts; its delivery is proportioned at all times to the speed of the compressor; it ceases automatically when the machine stops. Arrangements are such that the oil flowing through the bearings is returned to the crank basin to be used again and again with little loss. The economy of engine lubricant which this system affords is evident, as is also the perfect simplicity and entire adequacy of this method of oiling. It is to be particularly noted that this is a "flood," not a "splash" system of lubrication, so that there can be no uncertainty as to its operation. A web in the main frame casting, with an auxiliary stuffing box, prevents the condensed steam, which may work out along the steam piston rod, from mingling with the oil in the crank basin.

Main Frames

A glance at the main frame of the Class "O" compressor immediately suggests the powerful rolling mill engine which is probably subjected to heavier duty than any other engine. This part is, in fact, modeled

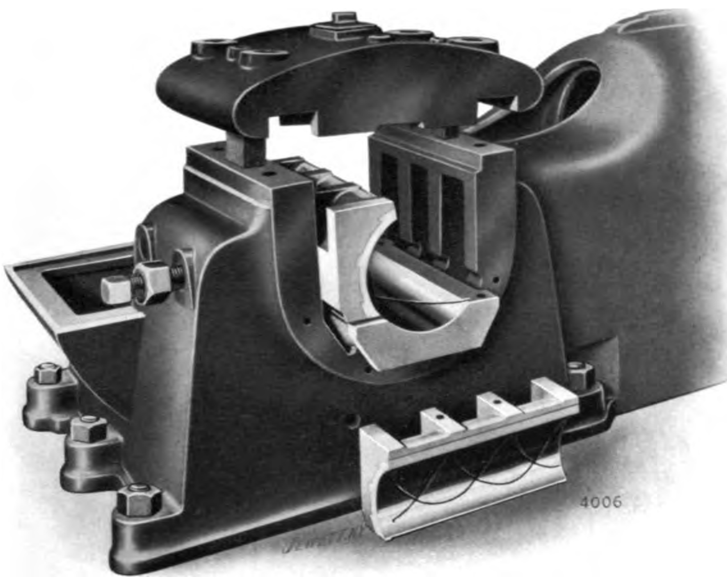


A Main Frame of a Class "O" Compressor, with one Main Bearing Complete

after rolling mill practice and is the most massive frame ever used on a compressor. It is supported under its entire length and the bottom is planed to rest true on the foundation. It is ribbed and reinforced in the best manner and is as strong as it is possible to make a solid casting. The rim carried around the crank section forms the oil basin for the lubricating system. The door on the side of the crosshead section can be opened for inspection with little effort.

Main Bearings

The illustration here shows, almost without description, the massive strength of the main bearing jaws and the arrangement of the boxes. It is almost impossible to conceive of any breakage or springing of



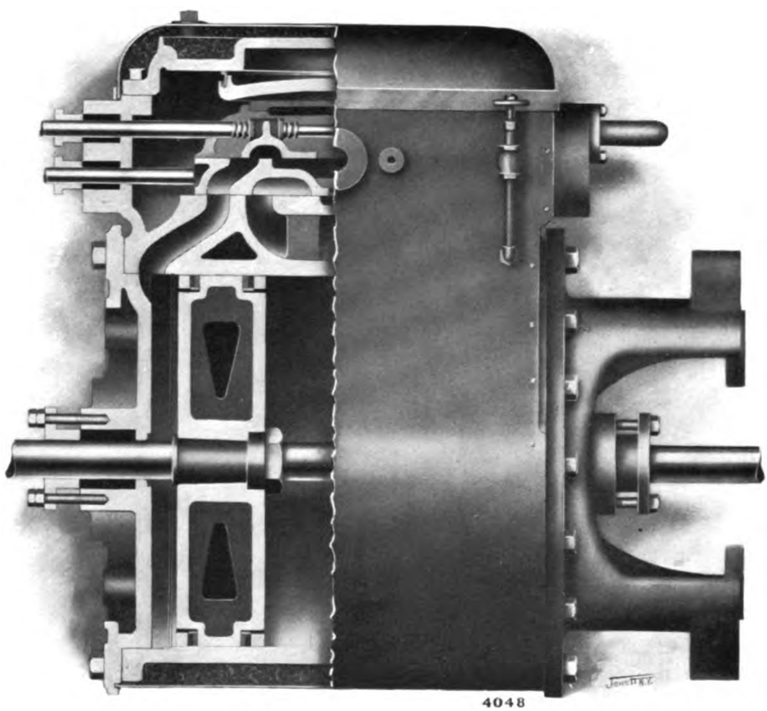
Class "O" Main Bearing, Partly Disassembled, Showing Method of Withdrawing Boxes

these vital parts in this design. It will be noted that planed surfaces on the three journal boxes normally coincide with planed surfaces in the bearing and cap. Locked bolts through the outer jaw give lateral adjustment, while cap bolts hold all in place. When necessary to inspect or renew the boxes, the shaft is lifted by a jack, just enough to remove pressure. The side adjusting bolts are loosened, the cap

having been previously removed. The side boxes can now be turned and lifted out. By sliding the eccentrics along the shaft the bottom boxes can be drawn out until the ribs on box and bearing clear, when the box is turned up around the shaft and removed. The side boxes proper are cast with dove-tails and heavily babbitted; the bottom boxes are of phosphor bronze.

Steam Cylinders

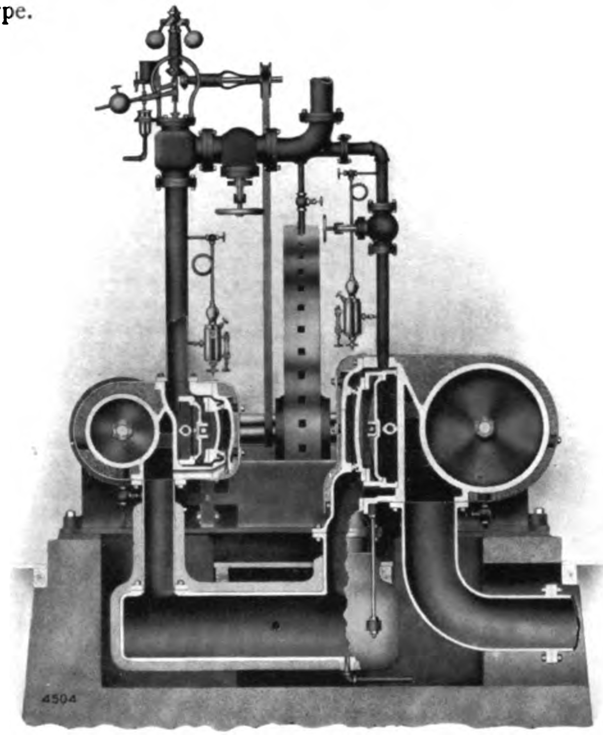
Steam cylinders and chests are completely insulated with a thick layer of nonconducting material enclosed in a planished steel lagging.



Half-Sectional Illustration of Class "O" Steam Cylinder and Steam Chest Showing Port Layout and Balanced Valve

The ports are wide and steam passages short and of large cross-section, to avoid wire-drawing and cooling of the steam. Steam valves are of balanced Meyer adjustable cut-off type with hand-wheel adjustment. In compound steam types the usual starting by-pass is provided for

admitting live steam to the low pressure cylinder when the high pressure side stops on center. The principles of the most up-to-date engine practice have been applied to the design of the steam end of these machines, with a view to the best economy obtainable from the Meyer valve type.

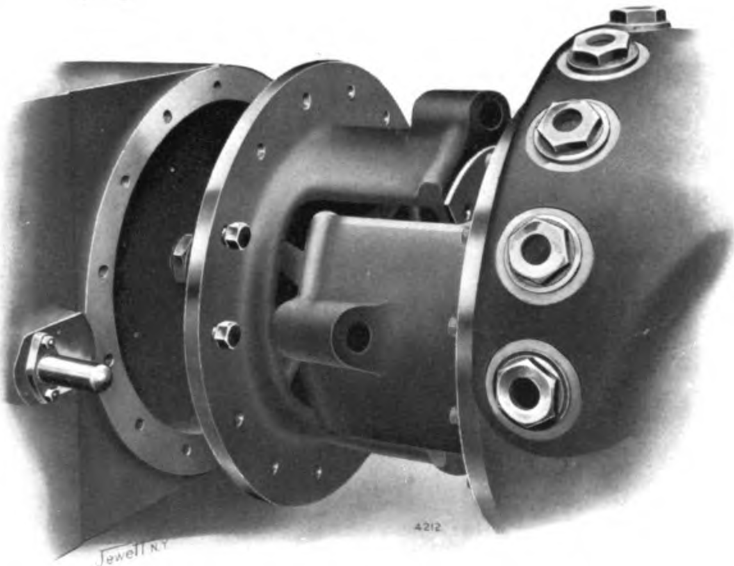


Transverse Section through Steam Cylinders, Steam Chests, and Steam Receiver of Class "O-3" and "O-4" Compressors

Distance Pieces

In all other duplex compressors with steam and air cylinders adjacent, it has been necessary to entirely disconnect and remove the outer cylinder before access could be had to the interior or to the piston of the inner cylinder. This difficult and costly process has been anticipated and avoided in Class "O" compressors by using the telescope distance piece illustrated on the next page. The two halves of this part normally coincide, meeting on a boss-and-counterbore joint with heavy through bolts affording all the strength and solidity of a solid casting. To reach the interior of the steam cylinder, or to remove the steam

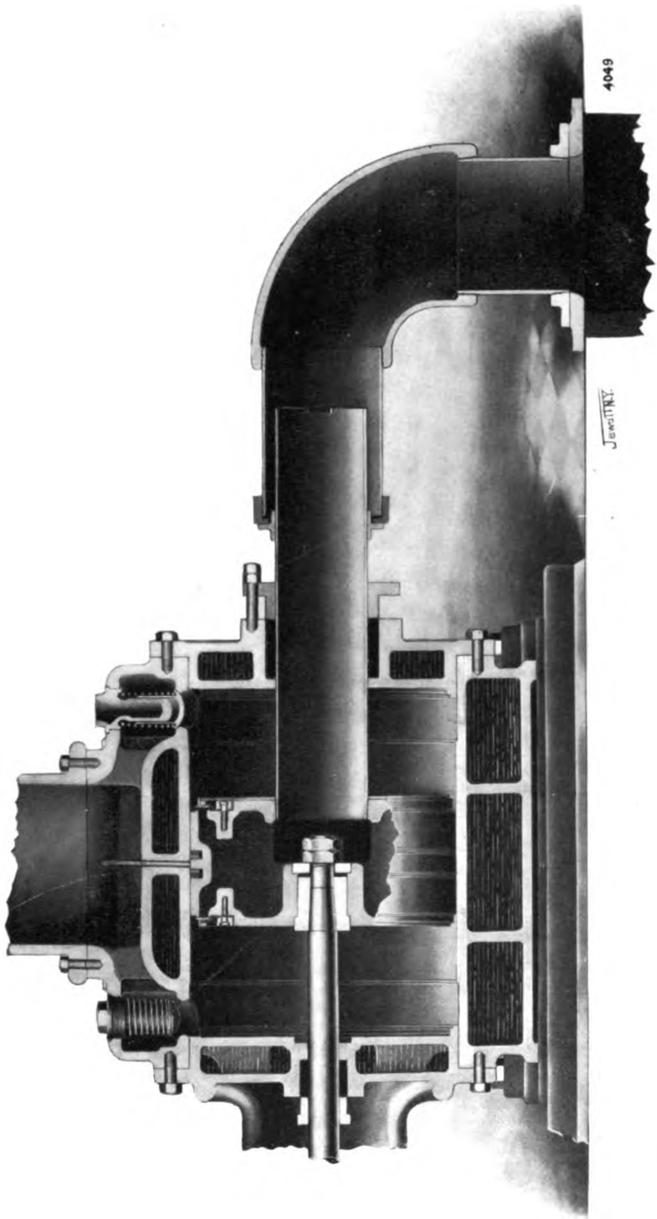
piston rings, the corresponding half of the distance piece is unbolted from the cylinder and the tap bolts holding the air cylinder to the sole plate are loosened, giving a little freedom of movement. The loose half of the distance piece can now be turned through a quarter of a circle on the piston rod and slipped back into the other half. In bolting up again, alignment cannot possibly be lost because of the arrangement of the joints, and when in normal position everything is exactly right.



The Telescope Distance Piece of Class "O" Compressors, Showing how Access is had to the Interior of the Steam Cylinder without Moving the Air End

The Air End

The massive design of the air end on Class "O" compressors corresponds with the distinct, heavy-duty character of the machine as a whole. Metal is generously but judiciously used, the air cylinders being supported for their full length on the sole plates. The cylinders are made with a full box construction underneath, instead of a foot, the entire box being a part of the water jacket and serving as a settling chamber. Where it is impossible to get clean water for jacket cooling, this settling chamber prevents the jacket space from filling up with mud or scale and maintains the efficiency of the jacket cooling. As there are no valves in the air heads, the latter are completely water



Longitudinal Section through the Air Cylinder of Class "O" Compressors, Showing Water Jackets on Heads and Barrel, "Hurricane-Inlet" Valves, "Cushioned Direct Lift" Discharge Valves, the Atmospheric Intake, and Large Air Passages

jacketed. As the head jacket is the most effective part of the jacket system, because the air in the cylinder is in contact with the head throughout the entire stroke, jacketing of this important part is kept in its most efficient form by a system of water circulation which forces the coolest water through both air heads before going to the cylinder jacket. The water enters the bottom of each head and flows out at the top, being piped from there to the bottom of each end of the cylinder. There is a single water discharge on the side of the cylinder at the top of the water space, this being piped into an open funnel connected with a drain pocket cast on the cylinder sole plate. Thus the flow of water is always visible and can be regulated properly. There is a large drain valve for the cylinder jacket and a single drain valve on both heads and for the water piping, all of these drains being piped direct to the main cylinder drain. All of this water and drain piping is attached to the cylinder as a regular part of the machine equipment. Large hand-holes with bolted covers are provided at the top and bottom of the cylinder, and jacket plugs are provided on the heads, so that all water spaces can be easily cleaned.

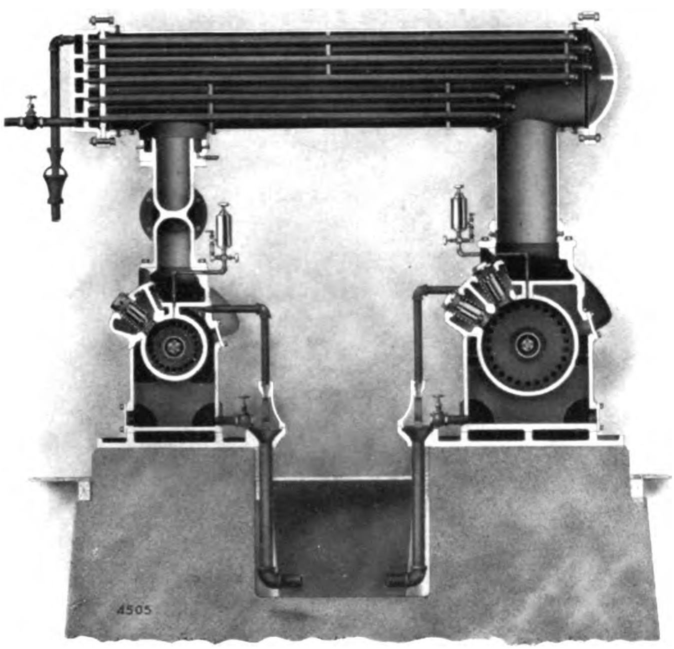
The air discharge passages are exceptionally large and free, the low pressure discharge being more than one-half the area of the low pressure cylinder. This not only gives the air a free passage as soon as it leaves the valves, but also adds additional receiver space to the intercooler. The discharge valves are arranged radially in the cylinder barrel. They are of large size and the removal of one or two admits of inspection of the interior of the cylinder.

The air inlet valves are of the standard "Hurricane-Inlet" pattern. Air discharge valves are of Ingersoll "Cushioned Direct Lift" type. As both of these valves are described in detail in pamphlet No. 3001 herewith, no further discussion of them will be presented here. One point only will be emphasized, viz., the unusually large inlet and discharge valve areas provided in the Class "O" type. The actual areas in any particular machine will be furnished on request. THE COMPANY INVITES A COMPARISON OF THE INLET AND DISCHARGE VALVE AREAS OF CLASS "O" COMPRESSORS WITH THOSE OF ANY OTHER COMPRESSOR ON THE MARKET.

The Intercooler

The intercooler in two stage types is set transversely above the air cylinders, supported by heavy cast cylinder connections. A glance at any of the illustrations of the complete machine will show the

unusually large size of the intercooler which gives a very liberal cooling area, large cross-section, low velocity of the air in transit, ample receiver capacity, and the best possible cooling economy. Pockets with drains provide for the removal of condensed moisture. Cooling water circulates through galvanized tubes which can be removed bodily from the intercooler shell. This is a very important feature as it allows the nest of tubes to be removed for cleaning on the outside, which is frequently necessary if the compressor is so placed that it



Transverse Section through Air Cylinders and Intercooler of Class "O-2" and "O-3" Compressors

cannot take in clean air. It is also a great convenience if any repairs on the cooler are called for. Baffle plates produce repeated transverse movement of the air over the tubes. The tubes, being free at one end and independent of the shell, can expand and contract without causing any leakage. The location of the air discharge pipe coming out above the high pressure cylinder is worthy of note as compared with those constructions in which it must be carried out below the floor, with special provision in the foundation.

Mechanical Efficiency

The mechanical efficiency of any compressor, which is the percentage of power available for useful work after the machine friction has been overcome, depends upon four things, viz., upon the best of workmanship throughout; upon the maintenance of true alignment, thus avoiding cramped bearings; upon the adequate lubrication of all bearings; and upon the provision of generous bearing surfaces, so that bearing pressures are moderate.

The workmanship of Class "O" compressors is of the standard Ingersoll-Rand quality, which means that it is the best which can be had. The care in enforcing alignment in Class "O" compressors has already been emphasized. This particular element in mechanical efficiency is in these machines still further assured by the massive construction which utterly prohibits any "springing" of the structure under the most severe load conditions. The method by which the lubrication problem is solved in these compressors is described in a previous section. Only the fourth element, therefore, entering into mechanical efficiency remains to be discussed.

Beginning with the main shaft bearings, the length and diameter of these have been increased beyond all previous compressor practice. The same may be said of crank and crosshead pin bearings, crosshead guide surfaces, and eccentric straps. The steam and air pistons are of the generous width which has long characterized all of this Company's machines. All stuffing boxes are long, so as to give a steam-and-air-tight working joint without a heavy gland pressure and without undue friction on the rods and inlet tubes. Examination of the construction of Class "O" compressors will result in a conviction that friction loss has been reduced in these machines to the practical limit.

Volumetric Efficiency

The volumetric efficiency of a compressor is the ratio of the volume of free air actually admitted and compressed in the intake cylinder, or cylinders, to the piston displacement. A high volumetric efficiency demands the admission to the cylinder of the maximum volume of free air as cool and dense as possible, and the compression and discharge of this entire admitted volume.

Class "O" compressors are marked by a very high volumetric efficiency which is the result of the following features: the admission of cool, clean air through the intake connections offered; the large

intake area of the "Hurricane-Inlet" valve, which is a higher percentage of the cylinder area than ordinary practice affords; the high density of the air admitted, the temperature of which cannot be perceptibly raised in entering the cylinder, because it never comes in contact with heated parts; the complete jacketing of the air cylinders; the jacketing of the entire air heads and the arrangement of water circulation by which the coldest water passes through the heads first; the large area and direct passages afforded by the "Cushioned Direct Lift" discharge valves which release the air freely; the exclusion of all air compressed, by the latter valves; the low percentage of clearance; and the sustained tightness of working parts, due to the splendid workmanship, to the generous bearing surfaces, and to the complete lubrication provided.

Large Capacity

This high volumetric efficiency, combined with the high rotative speed of Class "O" compressors, gives them a very large compressed air capacity as considered in connection with the floor space which they require. The speeds at which these machines are run would have been deemed prohibitive a few years ago. But the heavy structure, the large bearings, the unsurpassed oiling system, the improved valve movements, and the large valve and cooling areas, make these speeds entirely safe and practical.

Compression Efficiency

Compression efficiency in an air compressor is the ratio of the power theoretically required to produce a given pressure in a given volume of air, to the power actually required in the air cylinder to do this work. The modern understanding of compression efficiency is that it involves not only adequate cooling during compression, but also the discharge, with the least resistance, of the air compressed. Viewed in this light, compression efficiency is a question of getting the air into the cylinder with the least amount of work, of adequate cooling during compression, and of getting the air out of the cylinder with the least work. This understanding, therefore, presupposes large, free inlet and discharge valve areas as a primary requisite to a high compression efficiency. On a two stage compressor an efficient intercooler is also necessary.

All of these conditions are provided for in Class "O" compressors, as follows: by the admission of cool air through the large and well

cooled intake areas afforded by the "Hurricane-Inlet" valve; by the complete water jacketing of both cylinders and heads; by the highly efficient arrangement of jacket water circulation; by the exclusion of all heated air already compressed, by means of the superior discharge valves; by the large discharge valve areas and discharge passages; by the exceptionally large intercooler of special design, producing the maximum intercooling effect.

As both intake and discharge valves are automatic in their action and require no fixed setting or adjustment, the compression efficiency, in so far as it is dependent upon these parts, is the same in Class "O" compressors five or ten years after they have been running as when the machines are new. The natural result of all these refinements of design, which are never found in a cheap machine, is that the air card of Class "O" compressors indicates the minimum power for compression and the maximum compression efficiency.

The True Standard of Compressor Cost

A high-grade air compressor is always to be considered in the light of an investment, not of an expense. The measure of its value should be, not its first cost, but its capacity for earning profits on its first cost.

If the first cost of a compressor is to be the determining factor in reaching the decision to buy, the best basis of comparison is THE FIRST COST OF COMPRESSOR PER CUBIC FOOT OF FREE AIR COMPRESSED AND DELIVERED AT A STATED PRESSURE, this standard involving both volumetric and compression efficiencies.

As a second choice there remains a comparison of costs per cubic foot on the basis of GUARANTEED VOLUMETRIC CAPACITY IN CUBIC FEET OF FREE AIR COMPRESSED PER MINUTE, this standard involving volumetric efficiency alone.

As a third basis of comparison there is the cost per cubic foot based on THE PISTON DISPLACEMENT IN CUBIC FEET PER MINUTE of the machines under consideration. This is always a measurable quantity, and the cost of a compressor per cubic foot of piston displacement per minute is, in most cases, the only standard available for comparing compressor costs. In the latter case it needs no argument to show that, given two machines of the same cylinder diameter and stroke, one of which has a rated capacity one-third larger than the other due to its higher piston speed, the former machine represents at least equal value, considered merely on the basis of first cost, even at a price one-third higher than that of the latter machine. If the question of com-

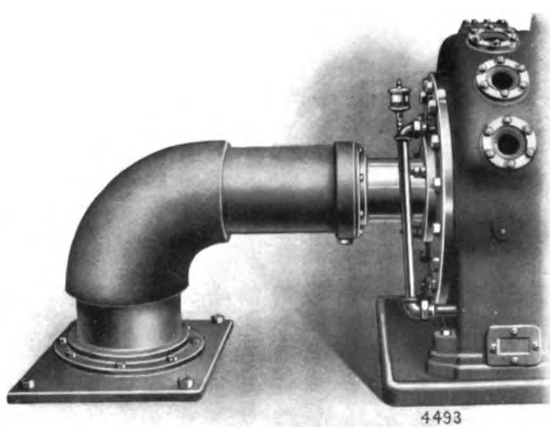
pactness is an important one, the former machine will represent actually better value than the latter.

Going still further than mere first cost, which is by no means the true standard for comparison, into the problem of earning power, it is evident that that compressor is the better investment which not only has a larger piston displacement, a higher volumetric efficiency, or a larger assured output of compressed air, but which also, owing to its superior construction, will continue its high initial performance with the fewest delays due to shut-down and with the least cost for repairs. Such a machine will maintain its high mechanical, volumetric, and compression efficiencies indefinitely; and even though the refinement of design and construction necessary to maintain these efficiencies may bring the first cost of that compressor higher than that of competing types, nevertheless it must be considered as the least expensive machine and its additional cost should be put down as a profitable investment, approved by good business judgment.

THE INGERSOLL-RAND COMPANY INVITES THE MOST CAREFUL COMPARISON OF CLASS "O" COMPRESSORS WITH ANY OTHER COMPRESSOR TYPES OFFERED TO THE TRADE, BY ANY OR ALL OF THE FOUR METHODS SUGGESTED IN THE PRECEDING PARAGRAPHS. NO EXPENSE HAS BEEN SPARED IN MAKING THESE MACHINES MEASURE UP TO THE HIGHEST STANDARDS OF COMPRESSOR VALUE.

Air Intake Connections

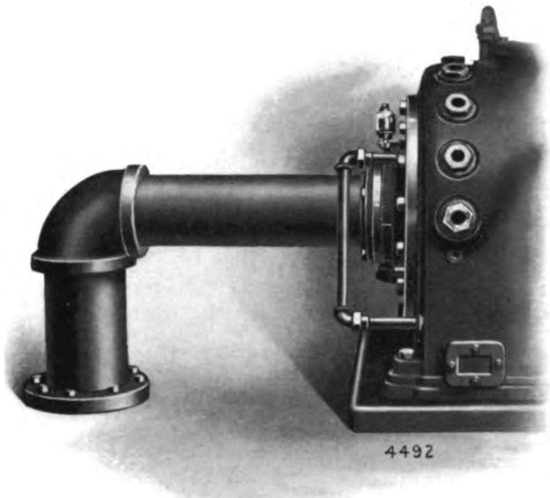
The "Hurricane-Inlet" valve used on Class "O" compressors lends itself with peculiar readiness to arrangements for admitting cool, clean air to the cylinders. The three following devices are offered, each of which may be connected by pipe or conduit to a suitable source of intake air.



The Standard Atmospheric Intake

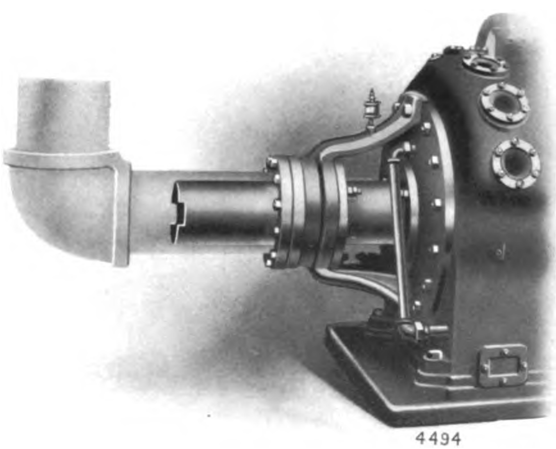
The ATMOSPHERIC INTAKE is intended for handling free air only. It is made with a cast footpiece for bolting to floor or foundation. There is no stuffing box, but the horizontal pipe surrounding the inlet tube is closed with a brass collar just clearing the tube, giving almost an air-tight connection.

The PRESSURE OR GAS INTAKE is very similar to the one just described, but the horizontal pipe is bolted over a gasket directly to the cylinder head. This is a perfectly tight intake, designed for handling any intake pressure or any vacuum. It has been developed especially for gas compression work.



The Special Pressure or Gas Intake

The EXTENSION BRACKET is simply a casting bolted to the cylinder head, with a single stuffing box around the inlet tube in addition to the regular stuffing box in the head. The customer may connect his inlet pipe to the outer flange on the bracket. This arrangement is suitable for intake pressures up to 50 pounds, or for vacuums not exceeding four or five inches.



The Special Intake Bracket

The Atmospheric Intake is a

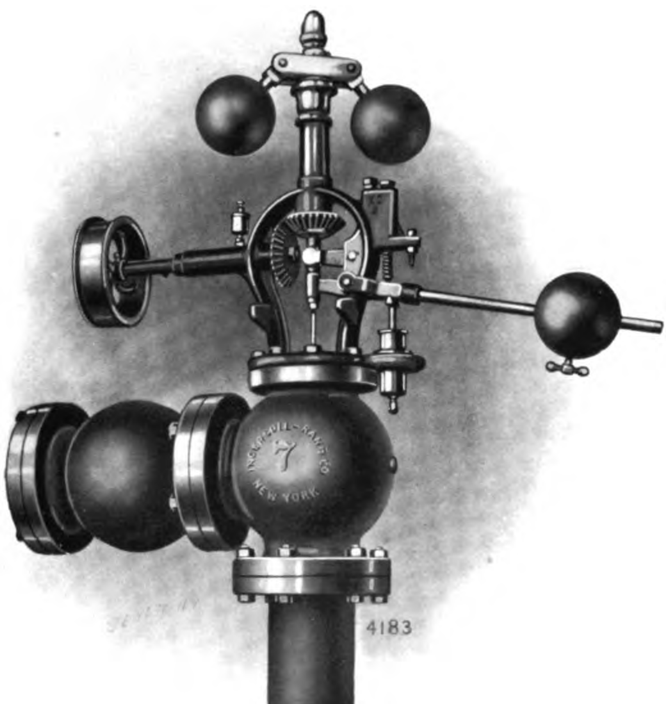
part of the standard equipment of Class "O" compressors, furnished without extra charge. The Extension Bracket will be substituted for the Atmospheric Intake, on order, without extra cost. The Pressure Intake, however, is a special feature, furnished only on specific order, at extra cost.

Packing

The stuffing boxes for steam and air piston rods, valve rods, and inlet tubes are so designed on Class "O" compressors as to take either plain or metallic packing, without special heads or other features. Semi-bronze packing is ordinarily furnished, however. Special metallic packings are furnished only on specific order, at extra cost.

Regulation

The standard Ingersoll-Rand "Air Ball Governor" is used on Class "O" compressors. This is a thoroughly practical combination of the ordinary fly-ball speed governor driven from the main shaft, with a



The Standard "Air Ball Governor" on Class "O" Compressors

pressure-regulating cylinder connected to the receiver. The fly-ball element is simply a speed-limiting device, preventing the machine from going beyond a safe number of revolutions per minute. The pressure cylinder operates, when normal air pressure is exceeded, to throttle the steam supply and thus reduce the speed and output of the compressor under partial load. A weighted lever opposing the pressure cylinder restores the steam supply and speed as load increases. The governor valve is balanced and the arrangement is peculiarly sensitive and quick-acting.

General Construction

In standards of materials, workmanship, interchangeability, inspection, and test, Class "O" compressors conform with the requirements as laid down in Pamphlet No. 3001 herewith, covering all Ingersoll-Rand compressors. The type is distinctly one for high duty under heavy service, offering to the trade everything that is most desirable in a reliable high-grade compressor.

Standard Classifications

The standard Class "O" type is offered in four different combinations of cylinders designated by the following symbols:

Class "O–1" — Duplex Steam and Duplex Air Cylinders
Class "O–2" — Duplex Steam and Compound Air Cylinders
Class "O–3" — Compound Steam and Compound Air Cylinders
Class "O–4" — Compound Steam and Duplex Air Cylinders

Sizes and Capacities

The standard sizes and capacities of Class "O" compressors are given in the tables on pages 23 and 24. This pamphlet is not intended to go into the minute details of construction of these machines. This latter information is set forth in the specifications which will be furnished to those asking for a quotation on a compressor to meet conditions as set forth in the request for information.

DUPLEX STEAM DRIVEN AIR COMPRESSORS, CLASS "O-1"

SIMPLE DUPLEX STEAM AND AIR CYLINDERS. FLOOD LUBRICATION **Steam Pressure, 80-150 Pounds. Air Pressure, 15-100 Pounds**

Telegraph Name	Cylinders — Inches: Diameters: Duplex Steam	Duplex Air	Stroke	R. P. M.	Piston Displacement Cu. Ft. per Minute	Air Pressure: Minimum	Maximum	I. H. P. in Steam Cylinders: Minimum	Maximum	Floor Space, Feet and Inches: Length	Width	Height
Ocjel	10	10¼	16	200	**555**	85	100	96	105	19-0	8-0	8-9
Ocjim	10	12¼	16	200	**792**	50	80	102	136	19-0	8-0	8-9
Ocjon	10	14¼	16	200	**1081**	35	45	112	132	19-0	8-0	8-9
Ocjup	10	16¼	16	200	**1403**	20	30	92	133	19-0	8-0	8-9
Ockal	12	12¼	18	180	**795**	90	100	140	149	21-6	8-6	9-0
Ockem	12	14¼	18	180	**1090**	60	85	153	183	21-6	8-6	9-0
Ockin	12	16¼	18	180	**1415**	40	55	157	192	21-6	8-6	9-0
Ockop	12	18¼	18	180	**1782**	30	35	163	182	21-6	8-6	9-0
Ockur	12	20¼	18	180	**2234**	15	25	124	184	21-6	8-6	9-0
Oclam	14	14¼	21	160	**1120**	95	100	205	210	24-6	9-0	9-3
Oclen	14	16¼	21	160	**1464**	70	90	223	258	24-6	9-0	9-3
Oclip	14	18¼	21	160	**1843**	55	65	248	275	24-6	9-0	9-3
Oclor	14	20¼	21	160	**2313**	35	50	257	296	24-6	9-0	9-3
Oclus	14	22¼	21	160	**2785**	25	30	227	257	24-6	9-0	9-3
Ocman	14	24¼	21	160	**3300**	15	25	184	272	24-6	9-0	9-3
Ocmep	16	16¼	24	140	**1457**	90	100	254	271	27-6	10-0	9-7
Ocmir	16	18¼	24	140	**1838**	75	100	294	345	27-6	10-0	9-7
Ocmos	16	20¼	24	140	**2308**	60	70	327	359	27-6	10-0	9-7
Ocmut	16	22¼	24	140	**2780**	45	55	329	374	27-6	10-0	9-7
Ocnap	16	24¼	24	140	**3296**	35	40	337	370	27-6	10-0	9-7
Ocner	16	26¼	24	140	**3913**	25	30	319	362	27-6	10-0	9-7
Ocnis	18	18¼	27	125	**1840**	90	100	321	342	33-6	11-6	10-0
Ocnot	18	20¼	27	125	**2310**	80	100	379	430	33-6	11-6	10-0
Ocnuv	18	22¼	27	125	**2785**	60	75	391	449	33-6	11-6	10-0
Ocohs	18	24¼	27	125	**3301**	45	55	386	438	33-6	11-6	10-0
Ocorb	18	26¼	27	125	**3920**	35	40	396	435	33-6	11-6	10-0
Ocras	18	28¼	27	125	**4530**	25	30	361	410	33-6	11-6	10-0
Ocret	18	30¼	27	125	**5190**	15	25	282	418	33-6	11-6	10-0

The HORSE POWER ratings given in the above are those that will be experienced when operating under sea level conditions. The power required will drop off slightly under altitude conditions.

DUPLEX STEAM DRIVEN AIR COMPRESSORS, CLASS "O-2"

Simple Duplex Steam Cylinders; Cross-Compound Two Stage Air Cylinders; Overhead Horizontal Intercooler; Flood Lubrication

For Sea Level, Steam Pressure 80-150 lbs. **Air Pressure 80-125 lbs.**

Telegraph Name	Cylinders, Inches: Diameters: Duplex Steam	Low Pressure Air Cylinder	High Pressure Air Cylinder	Stroke	R. P. M.	Piston Displacement Cu. Ft. per Minute	I. H. P. in Steam Cylinders at Air Pressure Given: Minimum	Standard	Maximum	Floor Space Feet & Inches: Length	Width	Height
High Duty							**90 lbs.**	**110 lbs.**	**125 lbs.**			
Obart	10	16¼	10¼	16	200	**701**	116	128	136	19-6	8-6	8-9
Obbay	12	19¼	12¼	18	180	**997**	163	180	192	22-0	9-0	9-0
Obcaz	14	22¼	13¼	21	160	**1392**	226	248	266	25-0	9-8	9-3
Obdab	16	25¼	15¼	24	140	**1799**	291	321	342	28-0	10-6	9-7
Obens	18	28¼	17¼	27	125	**2262**	362	399	426	32-0	12-0	10-0
Medium Duty							**80 lbs.**	**90 lbs.**	**100 lbs.**			
Obgad	10	17¼	10¼	16	200	**773**	121	128	136	19-6	8-6	8-9
Obint	12	20¼	12¼	18	180	**1117**	172	182	193	22-0	9-0	9-0
Objag	14	24¼	14¼	21	160	**1650**	253	266	282	25-0	9-8	9-3
Obmel	16	27¼	16¼	24	140	**2087**	320	336	357	28-0	10-6	9-7
Obpor	18	30¼	18¼	27	125	**2588**	390	412	438	32-0	12-0	10-0

AIR PRESSURE RATING—The use of high duty and medium duty air compressors is to be determined by the ratings given under the heading—"Indicated Horse Power in Steam Cylinders." High duty compressors are built for a continuous working air pressure of 110 lbs., the maximum pressure not to exceed 125 lbs. The medium duty compressors are built for a continuous working air pressure of 90 lbs., the maximum pressure not to exceed 100 lbs.

For Altitudes, Steam Pressure 80-150 lbs. **Air Pressure 90-115 lbs.**

Telegraph Name	Duplex Steam	Low Pressure Air Cylinder	High Pressure Air Cylinder	Stroke	R. P. M.	Piston Displacement Cu. Ft. per Minute	Minimum	Standard	Maximum	Length	Width	Height
5000 Feet							**90 lbs.**	**100 lbs.**	**115 lbs.**			
Obran	10	17¼	10¼	16	200	**778**	118	123	132	19-6	8-6	8-9
Obrep	12	20¼	12¼	18	180	**1117**	168	175	187	22-0	9-0	9-0
Obrir	14	24¼	13¼	21	160	**1650**	245	256	273	25-0	9-8	9-3
Obros	16	27¼	15¼	24	140	**2087**	310	324	346	28-0	10-6	9-7
Obrut	18	30¼	17¼	27	125	**2588**	380	396	425	32-0	12-0	10-0
10,000 Feet							**90 lbs.**	**100 lbs.**	**110 lbs.**			
Obser	10	18¼	10¼	16	200	**881**	120	125	131	19-6	8-6	8-9
Obsis	12	21¼	12¼	18	180	**1215**	163	172	179	22-0	9-0	9-0
Obsot	14	25¼	13¼	21	160	**1802**	239	252	262	25-0	9-8	9-3
Obsuv	16	28¼	15¼	24	140	**2259**	300	315	329	28-0	10-6	9-7
Obtar	18	32¼	17¼	27	125	**2971**	390	410	428	32-0	12-0	10-0

COMPOUND, AND LOW PRESSURE DUPLEX, STEAM CYLINDERS FOR CLASS "O" COMPRESSORS

High Duty, Medium Duty, and Altitudes

Standard Duplex Cylinders	Equivalent Compound Steam Cylinders — Condensing 90-125 lbs. Steam Pressure; Non-Condensing 100-125 lbs. Steam Pressure: * Telegraph Name	Diam. H. P. Cylinder Inches	Diam. L. P. Cylinder Inches	Condensing 130-150 lbs. Steam Pressure; Non-Condensing 130-150 lbs. Steam Pressure: * Telegraph Name	Diam. H. P. Cylinder Inches	Diam. L. P. Cylinder Inches	Equivalent Duplex Steam Cylinders for 60-80 lbs. Steam Pressure: * Telegraph Name	Diameter Inches
8½ × 14	Sculc	10	16	Sdodd	8½	16	Seanc	10
10 × 16	Scuth	12	19	Sdolc	10	19	Searh	12
12 × 18	Scydm	14	23	Sdonn	12	23	Sebat	14
14 × 21	Scyrp	16	27	Sdoss	14	27	Sebez	16
16 × 24	Sdegn	18	30	Sdott	16	30	Sebif	18
18 × 27	Sdiav	20	34	Sdraj	18	24	Sebos	20

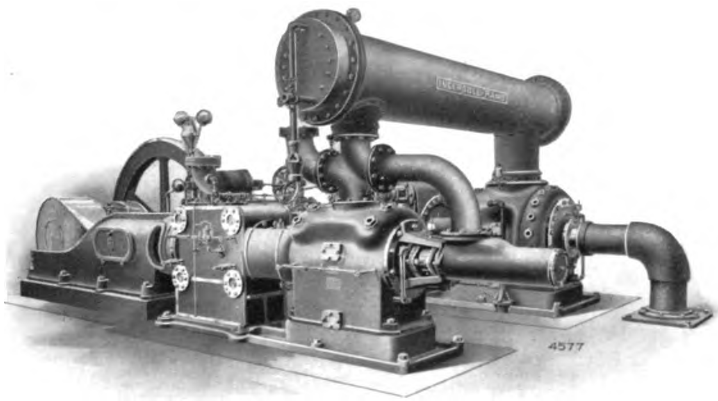
* These code words to be suffixed to code words for "O-1" and "O-2" Compressors to specify compressor with compound steam cylinders or with low pressure duplex steam cylinders.

CLASS "OC"
DUPLEX CORLISS STEAM DRIVEN
AIR COMPRESSORS

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Form No. 3023 April, 1910

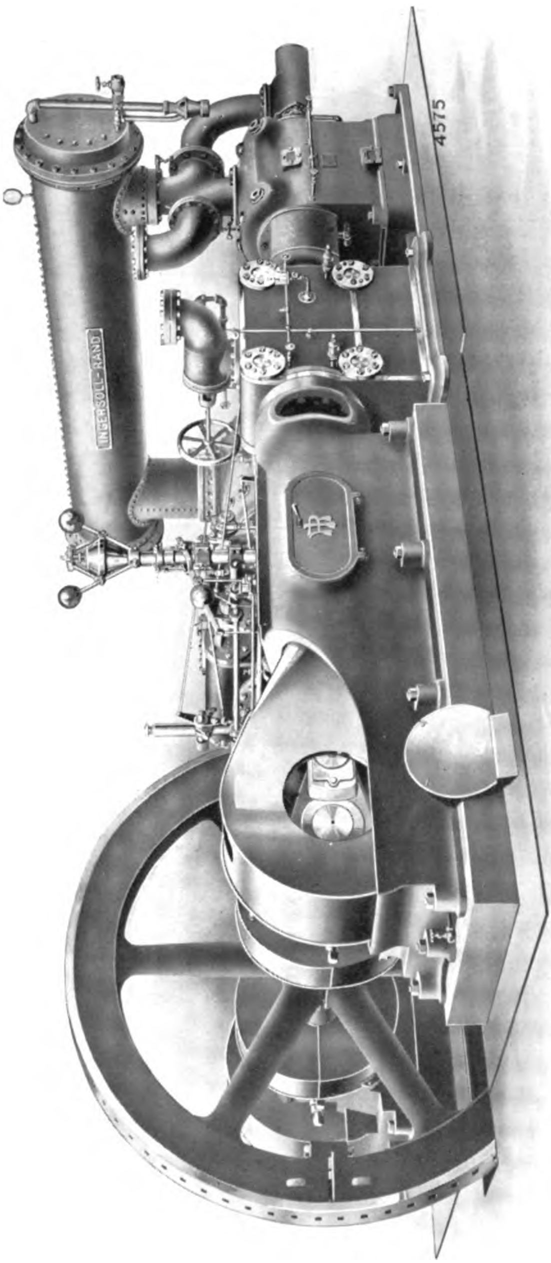


Class "OC-3" Steam Driven Air Compressor

A PERIOD of about forty years covers practically the entire history of the development of compressed air as a power; while only the past decade may be said to have witnessed the attainment of the commercial importance which compressed air merits. These last ten years have been wonderfully fruitful of improvements in pneumatic practice. But the trend of this development has been rather in the direction of improvements in details than in the development of entirely new machines.

Particularly is this found to be true when the air compressor — the fundamental basis of any compressed air system — is studied. New valve movements and valve designs, improved cooling devices, advances along the line of mechanical design, have brought the modern air compressor to a degree of economy and reliability hardly dreamed of fifteen or twenty years ago.

It has remained for the Ingersoll-Rand Company, the pioneer compressor builders of the world, to produce the first air compressors



Standard Class "OC-3" Steam Driven Air or Gas Compressor, with Cross-Compound Steam and Two Stage Compressing Cylinders with Intercooler

in which all of the latest improvements have been combined in a machine of distinctly modern design. In the large, straight line type, the Class "AA" steam driven, and the Class "BB" power driven, are such machines. In the duplex type the Class "PE" direct-connected electric, and the Class "PB" belt or rope drive, have established new standards of power driven construction. These four types are covered by separate pamphlets.

The present pamphlet is devoted to the Class "OC" steam driven compressor, which marks an advanced position in machines of this class which has never hitherto been reached. The Class "OC," the subject of this pamphlet, has Corliss steam valves. The same general type, however, is offered in the Class "O" compressor, to which a separate pamphlet (No. 3006) is devoted and which differs from the "OC" machine only in having Meyer adjustable cut-off steam valves.

General Type

The page illustration opposite gives a more clear idea of the Class "OC" compressor than any description can convey. It is of the familiar duplex type, with the steam cylinders next to the frames and separated from the air cylinders by open distance pieces.

In compound steam types the steam receiver is below the floor and set transversely. In compound air types the intercooler is transverse and above the cylinders. Frames are fully enclosed and a flood lubrication system is provided. Sole plates are placed under both steam and air cylinders. The distinctive features of the Class "OC" design are its massive, powerful construction and its simplicity. It is marked by a rugged strength, ample reserve power, and unlimited capacity for hard work.

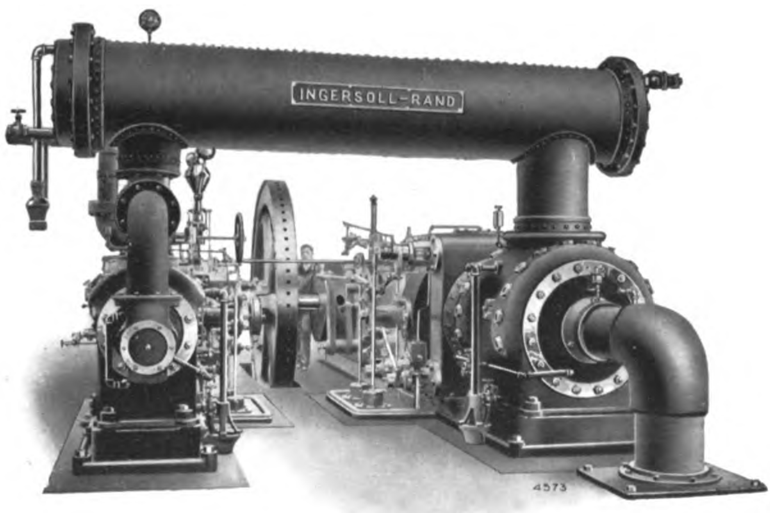
Simplicity

As compared with the straight line type, the duplex compressor has generally, and wrongly, been considered a rather complex machine, to be used only where constant attention and the best of skilled attendance could be given it. The design of the Class "OC" compressor, however, is marked by a simplicity fairly comparable with that of the "old reliable" straight line. It is a duplex compressor divested of all possible trouble-making elements, with inlet and discharge valves automatic at all speeds and pressures, requiring

no setting or adjusting. It can be entrusted with the most arduous duty without fear of a breakdown or rapid loss of efficiency.

Automatic Features

Second in importance only to simplicity, as related to operating conditions in the modern power plant, is the question of automatic action — the faculty for doing the requisite amount of work with the least possible attention under all load conditions. Class "OC" compressors are as completely automatic in action as it is possible to make a high-grade compressor. The "personal equation" of the attendant must always enter in some degree into the operation of a high-duty machine; but in this new type this element has been reduced to the practical limit. Automatic control of speed and pressure, and regulation of output to load, are provided by the "A-15 Governor" with which these compressors are fitted. The lubrication system, fully described later, is almost infallible and proportions the oil supply to the speed. The air valves simply take care of themselves.



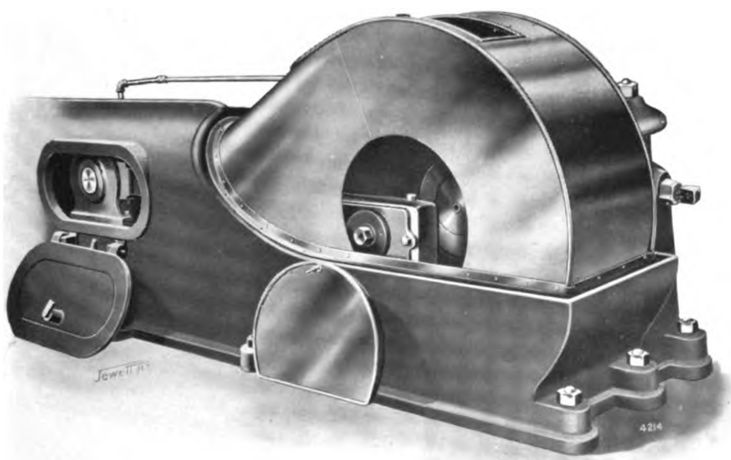
Air End View of Class "OC-3" Compressor, Illustrating the Accessibility of the Design

Accessibility

The floor plan of the Class "OC" compressor is roughly a letter "H." The machine is accessible inside and out. At one end are the main bearings and the eccentrics, easily reached. On the sides are the cranks, crossheads, and connecting rods, accessible while the machine is in operation through the front and top doors on the oil guards and through the large door on the side of the main frame. At the other end are the air cylinders, accessible on all sides. In the middle are the steam valve gear and the throttle. The steam cylinders are open to inspection on both sides. Air pistons can be withdrawn at the back. Steam piston rods can be taken out at the front end. The main bearing boxes can be removed or renewed without taking out the shaft.

Cleanliness

The enclosed construction over the cranks, around the crossheads, and surrounding the eccentrics absolutely prevents the throwing of oil from these parts. Double-grooved oil rings on the shaft prevent the escape of oil at this point. An oil rim around the valve guides



Oil Guard over Crank of Class "OC" Compressors, Showing Oil Doors in Guard and Frame, and the Enclosed Construction

collects oil and returns it to the crank basin. The sole plates beneath the air cylinders have rims preventing oil or water from running over the foundation.

Adaptability

The Class "OC" type has been designed to readily admit of any combination of driving and compressing elements to meet operating conditions. Steam cylinders may be simple or compound, condensing or noncondensing, using saturated or superheated steam at any pressure. The air cylinders may be simple duplex or cross-compound two stage, adapted for a wide range of air pressures. There is almost no combination of requirements, except a demand for very high air pressures, which cannot be satisfied in standard machines of this class.

Ease of Installation

The Class "OC" compressor has all the ease of installation which has hitherto characterized only machines of the bed-plate type. Frames, cylinders, and distance pieces come together with a boss-and-counterbore joint. A surfaced joint is provided between the sole plates and the cylinder foot-pieces.

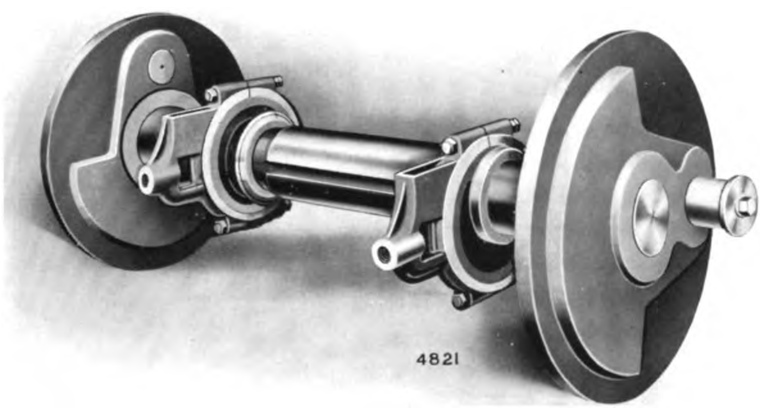
The shaft cannot be mounted out of line because planed surfaces on the main bearing boxes must coincide with planed surfaces in the main bearing jaws. Planed surfaces on main frames serve as leveling strips in setting up the machine.

The foundation is of a type easily built, and the foundation bolts are so disposed as to be easily spaced in their correct relation in building the foundation, and readily accessible. While the Class "OC" compressor is practically a solid unit when installed, yet it breaks up into parts handled with ease and convenience for transportation, for working in close quarters, for passing through restricted openings, or for placing on the foundation.

Duplex Characteristics

All of the recognized advantages of the duplex construction are embodied in Class "OC" compressors: the balanced construction with quartered cranks effecting an equalization of impulses and a mutual co-operation between the two halves of the compressor; the

reduction of operating stresses by this balanced construction; the absence of any dead center, admitting of automatic and economical operation over the entire load range; the ease with which either or both steam and air cylinders can be compounded, securing the attendant compound economies without an increased number of parts. It has already been seen that, in addition to these advantages, the Class "OC" possesses the solid, self-contained features of the straight line or of the bed-plate type of compressor. There can be no doubt that the duplex construction is the best for large, high-duty machines; and the Class "OC" compressor reveals the duplex type at its very best.



Main Shaft, Cranks, Eccentrics, and Eccentric Straps of Class "OC" Compressor

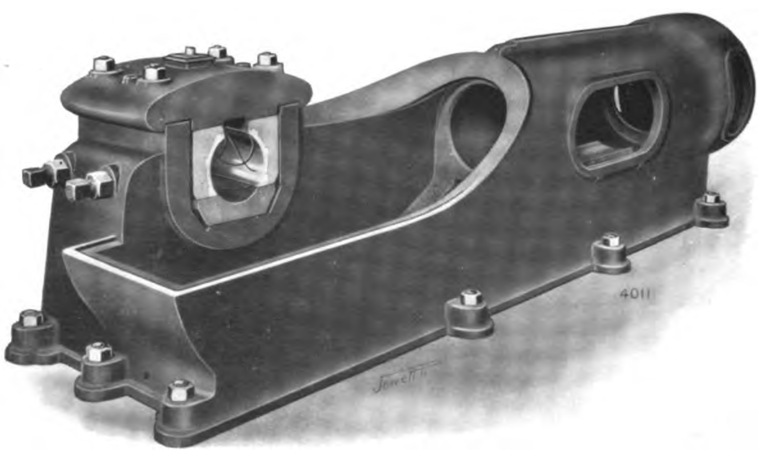
The Oiling System

The usual complement of high-grade sight-feed oilers, oil cups, lubricators, etc., is provided for the lubrication of steam and air cylinders, stuffing boxes, and steam valve gear. Hand oil pumps are also furnished on each steam cylinder. All other bearings, however, are supplied with oil by a "flood" system which this Company originated and developed to the only successful working basis. In the main frame is an oil basin with a quantity of oil into which the crank disks dip. In operation a small quantity of this oil is carried up on the edge of the disks and caught at the top in a wiper which

discharges it to a small pan or tank. Oil pipes lead from this pan to the main bearings, eccentrics, crank and crosshead pins, crosshead guides, and steam piston rods. Glass oil cups are set on the main bearings and on the crosshead guides through which the oil from the central system flows, thus showing the engineer at all times that the machine is getting an adequate supply of oil in these vital bearings. The flow of oil begins the moment the machine starts; its delivery is proportioned at all times to the speed of the compressor; it ceases automatically when the machine stops. Arrangements are such that the oil flowing through the bearings is returned to the crank basin to be used again and again with little loss. The economy of engine lubricant which this system affords is evident, as is also the perfect simplicity and entire adequacy of this method of oiling. It is to be particularly noted that this is a "flood," not a "splash" system of lubrication, so that there can be no uncertainty as to its operation. A web in the main frame casting, with an auxiliary stuffing box, prevents the condensed steam, which may work out along the steam piston rod, from mingling with the oil in the crank basin.

Main Frames

A glance at the main frame of the Class "OC" compressor immediately suggests the powerful rolling mill engine which is probably subjected to heavier duty than any other engine. This part is, in

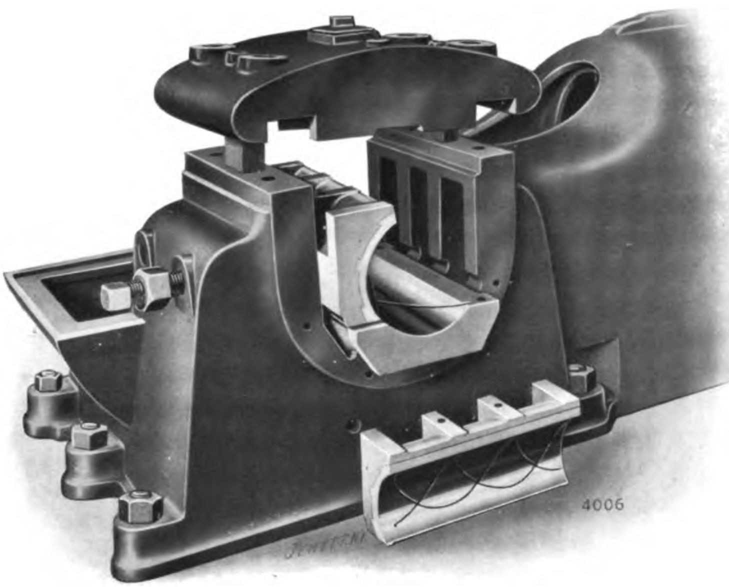


A Main Frame of a Class "OC" Compressor, with one Main Bearing Complete

fact, modeled after rolling mill practice and is the most massive frame ever used on a compressor. It is supported under its entire length and the bottom is planed to rest true on the foundation. It is ribbed and reinforced in the best manner and is as strong as it is possible to make a solid casting. The rim carried around the crank section forms the oil basin for the lubricating system. The door on the side of the crosshead section can be opened for inspection with little effort.

Main Bearings

The illustration here shows, almost without description, the massive strength of the main bearing jaws and the arrangement of the boxes. It is almost impossible to conceive of any breakage or



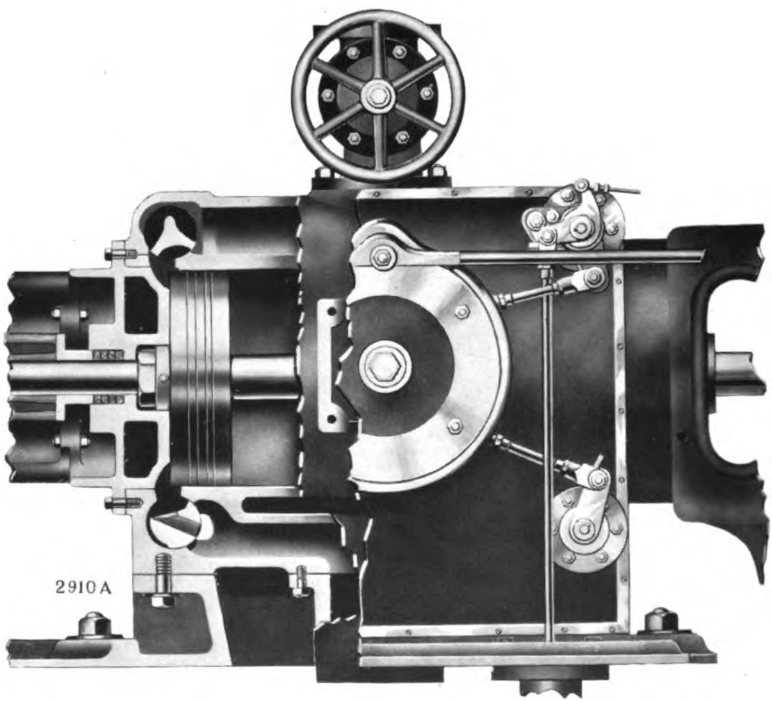
Class "OC" Main Bearing, Partly Disassembled, Showing Method of Withdrawing Boxes

springing of these vital parts in this design. It will be noted that planed surfaces on the three journal boxes normally coincide with planed surfaces in the bearing and cap. Locked bolts through the outer jaw give lateral adjustment, while cap bolts hold all in place. When necessary to inspect or renew the boxes, the shaft is lifted by a

jack, just enough to remove pressure. The side adjusting bolts are loosened, the cap having been previously removed. The side boxes can now be turned and lifted out. By sliding the eccentrics along the shaft the bottom boxes can be drawn out until the ribs on box and bearing clear, when the box is turned up around the shaft and removed. The side boxes proper are cast with dovetails and heavily babbitted; the bottom boxes are of phosphor bronze.

The Steam End

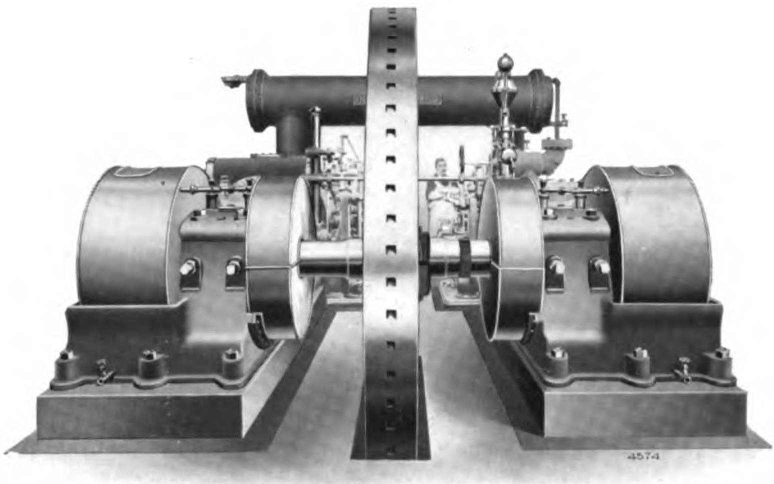
The steam end of Class "OC" compressors represents the latest and most advanced Corliss engine practice. Every precaution is



Half-Sectional Illustration of Class "OC" Steam Cylinder

taken to assure the highest steam economy. The cylinder heads are cast hollow. An air space separates the exhaust passage from the cylinder barrel. Cylinders are covered with mineral wool or magnesia and lagged with planished steel jackets.

The valve gear is of an improved Corliss liberating type, with vacuum dashpots and double-ported steam and exhaust valves. The latches of the gear are of hardened steel, with eight reversible and interchanging edges, which can be used in succession as wear occurs. Valve bonnets have renewable bronze bushings. The low pressure valve gear of "OC-3" and "OC-4" machines have a hand adjustment by which cut-off may be changed, while running, to adjust receiver pressure. A large steam receiver is placed below the floor in compound steam types, completely insulated.



Fly Wheel End View of Class "OC-3" Compressor, Showing Length of Main Bearings and Oil Guards over Cranks and Eccentrics

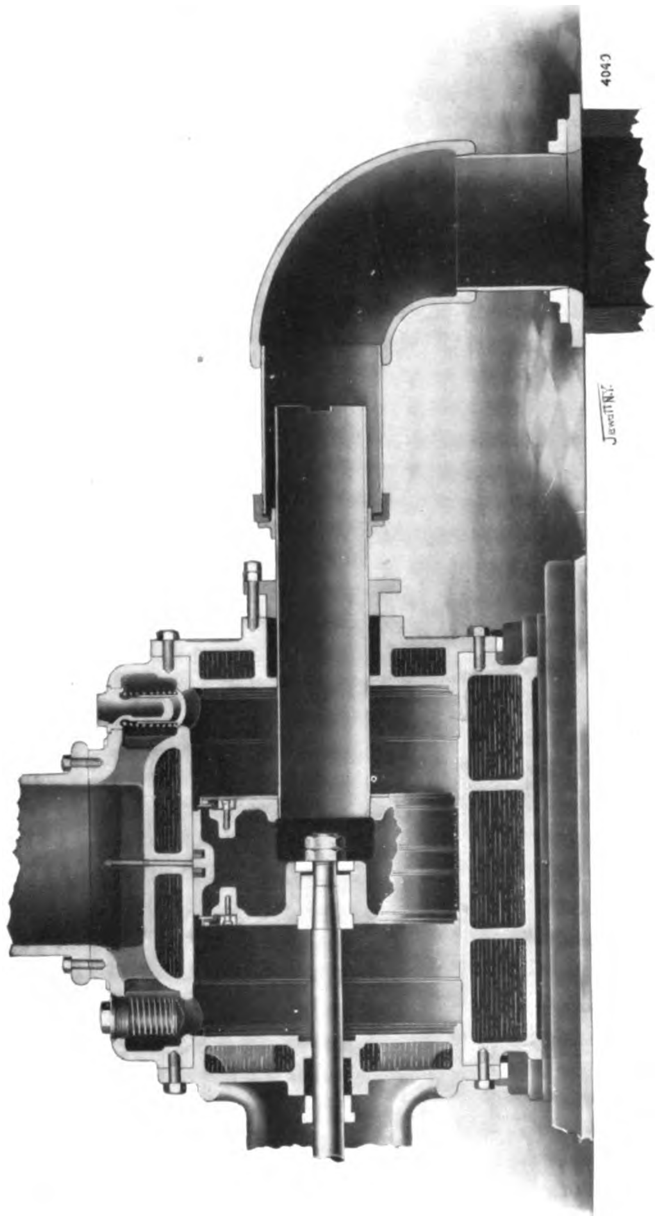
Distance Pieces and Sole-Plates

A heavy cast-iron distance piece, of open pattern, connects steam and air cylinders, giving ample strength with ready access to stuffing boxes. A continuous sole-plate is under the steam and air cylinders on each side, having a rim which catches oil or water and prevents its escape over the foundation. Both cylinders are secured to this sole-plate by cap bolts and can be removed without loosening foundation bolts or losing alignment of parts.

The Air End

The massive design of the air end on Class "OC" compressors corresponds with the distinct, heavy-duty character of the machine as a whole. Metal is generously but judiciously used, the air cylinders being supported for their full length on the sole-plates. The cylinders are made with a full box construction underneath, instead of a foot, the entire box being a part of the water jacket and serving as a settling chamber. Where it is impossible to get clean water for jacket cooling this settling chamber prevents the jacket space from filling up with mud or scale and maintains the efficiency of the jacket cooling. As there are no valves in the air heads, the latter are completely water jacketed. As the head jacket is the most effective part of the jacket system, because the air in the cylinder is in contact with the head throughout the entire stroke, jacketing of this important part is kept in its most efficient form by a system of water circulation which forces the coolest water through both air heads before going to the cylinder jacket. The water enters the bottom of each head and flows out at the top, being piped from there to the bottom of each end of the cylinder. There is a single water discharge on the side of the cylinder at the top of the water space, this being piped into an open funnel connected with a drain pocket cast on the cylinder sole-plate. Thus the flow of water is always visible and can be regulated properly. There is a large drain valve for the cylinder jacket and a single drain valve on both heads and for the water piping, all of these drains being piped direct to the main cylinder drain. All of this water and drain piping is attached to the cylinder as a regular part of the machine equipment. Large hand-holes with bolted covers are provided at the top and bottom of the cylinder, and jacket plugs are provided on the heads, so that all water spaces can be easily cleaned.

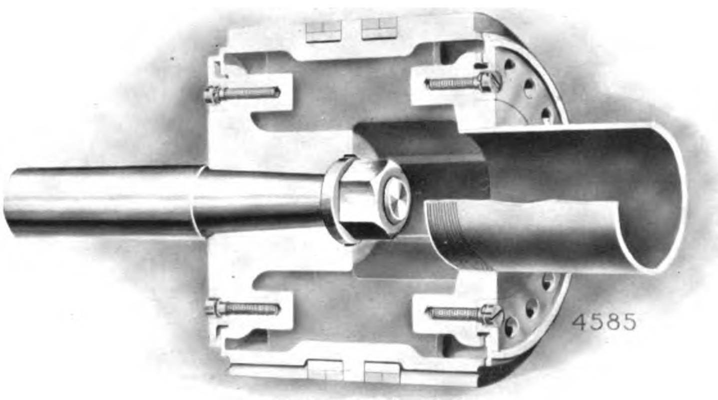
The air discharge passages are exceptionally large and free, the low pressure discharge being more than one-half the area of the low pressure cylinder. This not only gives the air a free passage as soon as it leaves the valves, but also adds additional receiver space to the intercooler. The discharge valves are arranged radially in the cylinder barrel. They are of large size and the removal of one or two admits of inspection of the interior of the cylinder. Particular attention is called, in the sectional illustration on the following page, to the exceptionally complete jacketing of the cylinder and to the unusually generous provision made for admitting and discharging the air freely.



Longitudinal Section through the Air Cylinder of Class "OC" Compressors, Showing Water Jackets on Heads and Barrel, "Hurricane-Inlet" Valves, "Cushioned Direct Lift" Discharge Valves, the Atmsopheric Intake, and Large Air Passages

The Air Valves

The air inlet valves are of the standard "Hurricane-Inlet" pattern. Air discharge valves are of Ingersoll "Cushioned Direct Lift" type. As both of these valves are described in detail in pamphlet No. 3001, no further discussion of them will be presented here. One point only will be emphasized, viz., the unusually large inlet and



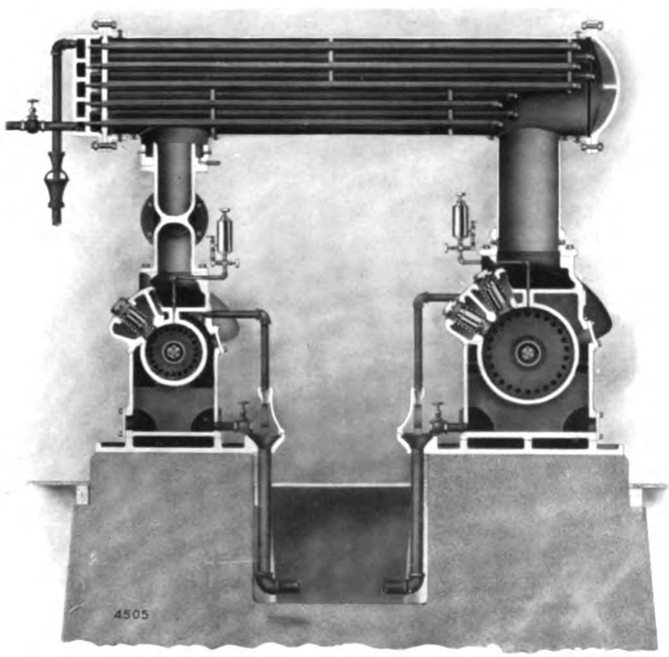
A Standard "Hurricane-Inlet" Valve Piston in section

discharge valve areas provided in the Class "OC" type. The very important bearing which the design of these valves has on the economy and capacity of these compressors is explained more fully in the discussion of volumetric efficiency on pages 16 and 17 of this pamphlet. The actual areas in any particular machine will be furnished on request. THE COMPANY INVITES A COMPARISON OF THE INLET AND DISCHARGE VALVE AREAS OF CLASS "OC" COMPRESSORS WITH THOSE OF ANY OTHER COMPRESSOR ON THE MARKET.

The Intercooler

The intercooler in two stage types is set transversely above the air cylinders, supported by heavy cast cylinder connections. A glance at any of the illustrations of the complete machine will show the unusually large size of the intercooler which gives a very liberal cooling area, large cross-section, correct velocity of the air in transit,

ample receiver capacity, and the best possible cooling economy. Pockets with drains provide for the removal of condensed moisture. Cooling water circulates through galvanized tubes which can be removed bodily from the intercooler shell. This is a very important feature, as it allows the nest of tubes to be removed for cleaning on the outside, which is frequently necessary if the compressor is so



Transverse Section through Air Cylinders and Intercooler of Class "OC-2" and "OC-3" Compressors

placed that it cannot take in clean air. It is also a great convenience if any repairs on the cooler are called for. Baffle plates produce repeated transverse movement of the air over the tubes. The tubes, being free at one end and independent of the shell, can expand and contract without causing any leakage. The location of the air discharge pipe coming out above the high pressure cylinder is worthy of note as compared with those constructions in which it must be carried out below the floor, with special provision in the foundation.

Mechanical Efficiency

The mechanical efficiency of any compressor, which is the percentage of power available for useful work after the machine friction has been overcome, depends upon four things, viz., upon the best of workmanship throughout; upon the maintenance of true alignment, thus avoiding cramped bearings; upon the adequate lubrication of all bearings; and upon the provision of generous bearing surfaces, so that bearing pressures are moderate.

The workmanship of Class "OC" compressors is of the standard Ingersoll-Rand quality, which means that it is the best which can be had. The care in enforcing alignment in Class "OC" compressors has already been emphasized. This particular element in mechanical efficiency is in these machines still further assured by the massive construction which utterly prohibits any "springing" of the structure under the most severe load conditions. The method by which the lubrication problem is solved in these compressors is described in a previous section. Only the fourth element, therefore, entering into mechanical efficiency remains to be discussed.

Beginning with the main shaft bearings, the length and diameter of these have been increased beyond all previous compressor practice. The same may be said of crank and crosshead pin bearings, crosshead guide surfaces, and eccentric straps. The steam and air pistons are of the generous width which has long characterized all of this Company's machines. All stuffing boxes are long, so as to give a steam-and-air-tight working joint without a heavy gland pressure and without undue friction on the rods and inlet tubes. Examination of the construction of Class "OC" compressors will result in a conviction that friction loss has been reduced in these machines to the practical limit.

Volumetric Efficiency

The volumetric efficiency of a compressor is the ratio of the volume of free air actually admitted and compressed in the intake cylinder, or cylinders, to the piston displacement. A high volumetric efficiency demands the admission to the cylinder of the maximum volume of free air as cool and dense as possible, and the compression and discharge of this entire admitted volume.

Class "OC" compressors are marked by a very high volumetric efficiency which is the result of the following features: the admission

of cool, clean air through the intake connections offered; the large intake area of the "Hurricane-Inlet" valve, which is a higher percentage of the cylinder area than ordinary practice affords; the high density of the air admitted, the temperature of which cannot be perceptibly raised in entering the cylinder, because it never comes in contact with heated parts; the complete jacketing of the air cylinders; the jacketing of the entire air heads and the arrangement of water circulation by which the coldest water passes through the heads first; the large area and direct passages afforded by the "Cushioned Direct Lift" discharge valves which release the air freely; the exclusion of all air compressed, by the latter valves; the low percentage of clearance; and the sustained tightness of working parts, due to the splendid workmanship, to the generous bearing surfaces, and to the complete lubrication provided.

Large Capacity

This high volumetric efficiency, combined with the high rotative speed of Class "OC" compressors, gives them a very large compressed air capacity considering the floor space which they require. The speeds at which these machines are run would have been deemed prohibitive in Corliss types a few years ago. But the heavy structure, the large bearings, the unsurpassed oiling system, the improved valve movements, and the large valve and cooling areas, make these speeds entirely safe and practical.

Compression Efficiency

Compression efficiency in an air compressor is the ratio of the power theoretically required to produce a given pressure in a given volume of air, to the power actually required in the air cylinder to do this work. The modern understanding of compression efficiency is that it involves not only adequate cooling during compression, but also the discharge, with the least resistance, of the air compressed. Viewed in this light, compression efficiency is a question of getting the air into the cylinder with the least amount of work, of adequate cooling during compression, and of getting the air out of the cylinder with the least work. This understanding, therefore, presupposes large, free inlet and discharge valve areas as a primary requisite to a high compression efficiency. On a two stage compressor an efficient intercooler is also necessary.

All of these conditions are provided for in Class "OC" compressors, as follows: by the admission of cool air through the large and well cooled intake areas afforded by the "Hurricane-Inlet" valve; by the complete water jacketing of both cylinders and heads; by the highly efficient arrangement of jacket water circulation; by the exclusion of all heated air already compressed, by means of the superior discharge valves; by the large discharge valve areas and discharge passages; by the exceptionally large intercooler of special design, producing the maximum intercooling effect.

As both intake and discharge valves are automatic in their action and require no fixed setting or adjustment, the compression efficiency, in so far as it is dependent upon these parts, is the same in Class "OC" compressors five or ten years after they have been running as when the machines are new. The natural result of all these refinements of design, which are never found in a cheap machine, is that the air card of Class "OC" compressors indicates the minimum power for compression and the maximum compression efficiency.

The True Standard of Compressor Cost

A high-grade air compressor is always to be considered in the light of an investment, not of an expense. The measure of its value should be, not its first cost, but its capacity for earning profits on its first cost.

If the first cost of a compressor is to be the determining factor in reaching the decision to buy, the best basis of comparison is THE FIRST COST OF COMPRESSOR PER CUBIC FOOT OF FREE AIR COMPRESSED AND DELIVERED AT A STATED PRESSURE, this standard involving both volumetric and compression efficiencies.

As a second choice there remains a comparison of costs per cubic foot on the basis of GUARANTEED VOLUMETRIC CAPACITY IN CUBIC FEET OF FREE AIR COMPRESSED PER MINUTE, this standard involving volumetric efficiency alone.

As a third basis of comparison there is the cost per cubic foot based on THE PISTON DISPLACEMENT IN CUBIC FEET PER MINUTE of the machines under consideration. This is always a measurable quantity, and the cost of a compressor per cubic foot of piston displacement per minute is, in most cases, the only standard available for comparing compressor costs. In the latter case it needs no argument to show that, given two machines of the same cylinder diameter and stroke, one of which has a rated capacity one-third larger than the other due

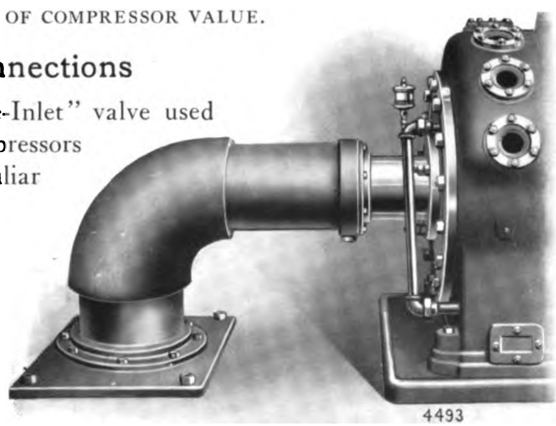
to its higher piston speed, the former machine represents at least equal value, considered merely on the basis of first cost, even at a price one-third higher than that of the latter machine. If the question of compactness is an important one, the former machine will represent actually better value than the latter.

Going still further than mere first cost, which is by no means the true standard for comparison, into the problem of earning power, it is evident that that compressor is the better investment which not only has a larger piston displacement, a higher volumetric efficiency, or a larger assured output of compressed air, but which also, owing to its superior construction, will continue its high initial performance with the fewest delays due to shut-down and with the least cost for repairs. Such a machine will maintain its high mechanical, volumetric, and compression efficiencies indefinitely; and even though the refinement of design and construction necessary to maintain these efficiencies may bring the first cost of that compressor higher than that of competing types, nevertheless it must be considered as the least expensive machine and its additional cost should be put down as a profitable investment, approved by good business judgment.

THE INGERSOLL-RAND COMPANY INVITES THE MOST CAREFUL COMPARISON OF CLASS "OC" COMPRESSORS WITH ANY OTHER CORLISS TYPES OFFERED TO THE TRADE, BY ANY OR ALL OF THE METHODS SUGGESTED IN THE PRECEDING PARAGRAPHS. NO EXPENSE HAS BEEN SPARED IN MAKING THESE MACHINES MEASURE UP TO THE HIGHEST STANDARDS OF COMPRESSOR VALUE.

Air Intake Connections

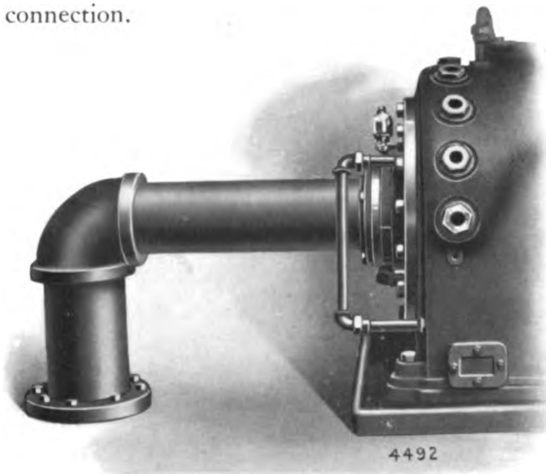
The "Hurricane-Inlet" valve used on Class "OC" compressors lends itself with peculiar readiness to arrangements for admitting cool, clean air to the cylinders. The three following devices are offered, each of which may be connected by pipe or conduit to a suitable source of intake air.



The Standard Atmospheric Intake

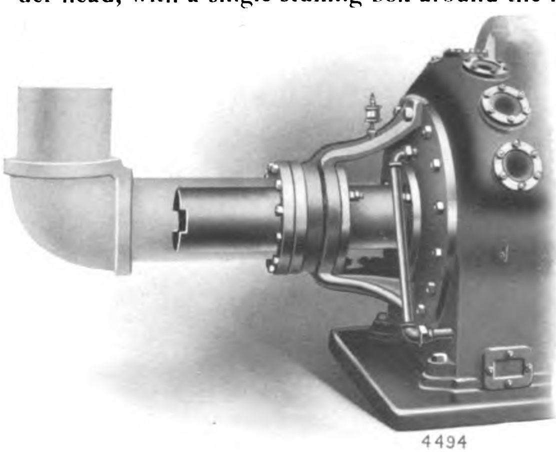
The ATMOSPHERIC INTAKE is intended for handling free air only. It is made with a cast foot-piece for bolting to floor or foundation. There is no stuffing box, but the horizontal pipe surrounding the inlet tube is closed with a brass collar just clearing the tube, giving almost an air-tight connection.

The PRESSURE OR GAS INTAKE is very similar to the one just described, but the horizontal pipe is bolted over a gasket directly to the cylinder head. This is a perfectly tight intake, designed for handling any intake pressure or any vacuum. It has been developed especially for gas compression work.



The Special Pressure or Gas Intake

The EXTENSION BRACKET is simply a casting bolted to the cylinder head, with a single stuffing box around the inlet tube in addition to the regular stuffing box in the head. The customer may connect his inlet pipe to the outer flange on the bracket. This arrangement is suitable for intake pressures up to 50 pounds, or for vacuums not exceeding four or five inches.

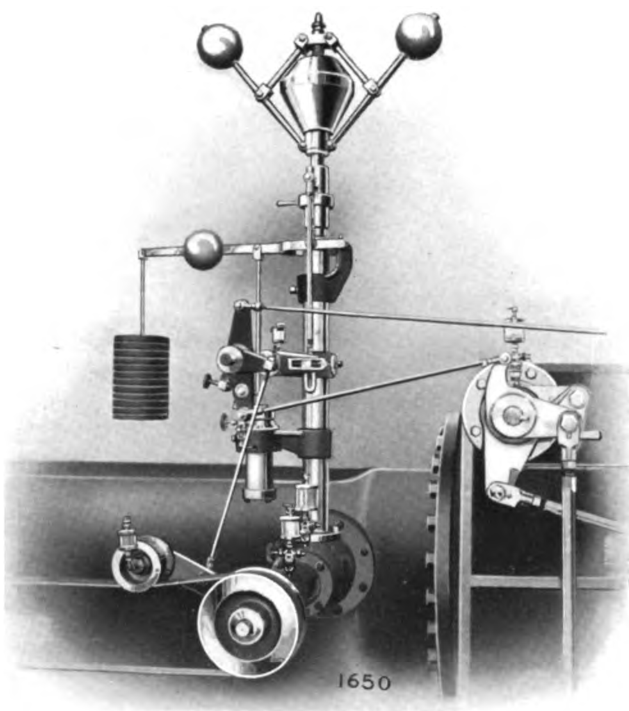


The Special Intake Bracket

The Atmospheric Intake is a part of the standard equipment of Class "OC" compressors, furnished without extra charge. The Extension Bracket will be substituted for the Atmospheric Intake, on order, without extra cost. The Pressure Intake, however, is a special feature, furnished only on specific order, at extra cost.

Regulation

The standard Ingersoll-Rand "A-15 Governor" is used on Class "OC" compressors. This is a thoroughly practical combination of the ordinary fly-ball speed governor driven from the main shaft, with a pressure-regulating cylinder connected to the receiver. The fly-ball element is simply a speed-limiting device, preventing the machine from going beyond a safe number of revolutions per minute.



The Standard "A-15 Governor" on Class "OC" Compressors

The pressure cylinder operates, when normal air pressure is exceeded, to change the cut-off and thus reduce the speed and output of the compressor under partial load. A weighted lever opposing the pressure cylinder restores the cut-off and speed as load increases. The arrangement is peculiarly sensitive and quick-acting.

Packing

The stuffing boxes for steam and air piston rods, valve rods, and inlet tubes are so designed on Class "OC" compressors as to take either plain or metallic packing, without special heads or other features. Fibrous packing is ordinarily furnished, however. Special metallic packings are furnished only on specific order, at extra cost.

General Construction

In standards of materials, workmanship, interchangeability, inspection, and test, Class "OC" compressors conform with the requirements as laid down in pamphlet No. 3001, covering all Ingersoll-Rand compressors. The type is distinctly one for high duty under heavy service, offering to the trade everything that is most desirable in a reliable high-grade Corliss compressor.

Standard Classifications

The standard Class "OC" type is offered in four different combinations of cylinders designated by the following symbols:

Class "OC-1" — Duplex Steam and Duplex Air Cylinders.
Class "OC-2" — Duplex Steam and Compound Air Cylinders.
Class "OC-3" — Compound Steam and Compound Air Cylinders.
Class "OC-4" — Compound Steam and Duplex Air Cylinders.

Sizes and Capacities

The standard sizes and capacities of Class "OC" compressors are given in the tables on pages 23 and 24. This pamphlet is not intended to go into the minute details of construction of these machines. This latter information is set forth in the specifications which will be furnished to those asking for a quotation on a compressor to meet conditions as set forth in the request for information.

Duplex Corliss Steam Driven Air Compressors
Class "OC-1"

SIMPLE DUPLEX STEAM AND AIR CYLINDERS
FLOOD LUBRICATION

Steam Pressure, 90-120 Pounds **Air Pressure, 15-100 Pounds**

Telegraph Name	Cylinders, In. Diameters			R.P.M.	Piston Displacement Cubic Feet per Minute	Air Pressure		I.H.P. in Steam Cylinders		Floor Space, Feet and Inches			
	Duplex Steam	Duplex Air	Stroke			Minimum	Maximum	Minimum	Maximum	Length Close Coupled	Length with Piston Rod Coupling	Width	Height
Oddek...	16	18¼	24	110 134	1442 1758	75	100	231 281	272 331	27- 6	31- 0	13- 0	7-0
Oddil....	16	20¼	24	110 134	1810 2208	60	70	257 313	282 344	27- 7	31- 1	13- 1	7-0
Oddom...	16	22¼	24	110 134	2182 2660	45	55	261 318	296 361	27- 8	31- 2	13- 1	7-0
Oddun...	16	24¼	24	110 134	2590 3155	35	40	265 323	291 354	27-10	31- 4	13- 2	7-0
Odemy ..	16	26¼	24	110 134	3072 3745	25	30	251 305	284 346	28- 0	31- 6	13- 3	7-0
Odenz...	18	20¼	27	100 125	1848 2310	80	100	304 379	344 430	29- 9	33- 3	13- 8	7-9
Oderc ...	18	22¼	27	100 125	2228 2785	60	75	313 391	360 449	29-10	33- 4	13- 9	7-9
Odfel....	18	24¼	27	100 125	2640 3301	45	55	309 386	351 438	29-11	33- 5	13-11	7-9
Odfon ...	18	26¼	27	100 125	3135 3920	35	40	317 396	348 435	30- 0	33- 6	14- 0	7-9
Odfup...	18	28¼	27	100 125	3625 4530	25	30	289 361	328 410	30- 1	33- 7	14- 1	7-9
Odgal ...	18	30¼	27	100 125	4150 5190	15	25	226 282	334 418	30- 3	33- 9	14- 3	7-9
Odgur...	20	22¼	30	95 120	2348 2965	80	100	381 481	433 546	32- 0	35- 6	14- 9	8-8
Odham ..	20	24¼	30	95 120	2785 3520	60	75	387 488	444 560	32- 1	35- 7	14- 9	8-8
Odhor...	20	26¼	30	95 120	3310 4180	50	55	415 524	439 555	32- 2	35- 8	14-10	8-8
Odhus...	20	28¼	30	95 120	3825 4835	40	45	422 532	453 572	32- 3	35- 9	14-10	8-8
Odily....	20	30¼	30	95 120	4370 5520	30	35	399 504	444 560	32- 4	35-10	15- 0	8-8
Odjan ...	20	32¼	30	95 120	5020 6340	15	28	273 345	439 555	32- 6	36- 0	15- 0	8-8
Odjep ...	22	24¼	36	80 100	2808 3510	90	100	482 602	512 640	37- 2	40-10	15- 6	9-9
Odjos....	22	26¼	36	80 100	3336 4170	70	85	503 628	565 706	37- 3	40-11	15- 7	9-9
Odjut ...	22	28¼	36	80 100	3856 4820	55	65	503 627	558 697	37- 4	41- 0	15- 8	9-9
Odkap...	22	30¼	36	80 100	4411 5508	45	50	513 641	554 692	37- 5	41- 1	15- 9	9-9
Odkot...	22	32¼	36	80 100	5060 6325	35	40	503 628	551 689	37- 6	41- 2	15-10	9-9
Odlar....	22	34¼	36	80 100	5611 7014	30	35	508 635	568 710	37- 7	41- 3	15-11	9-9
Odlit....	22	36¼	36	80 100	6430 8037	15	28	347 433	558 697	37- 8	41- 4	16- 0	9-9

DUPLEX STEAM DRIVEN AIR COMPRESSORS
CLASS "OC-2"

Simple Duplex Steam Cylinders; Cross-Compound Two Stage Air Cylinders; Overhead Horizontal Intercooler; Flood Lubrication

For Sea Level, Steam Pressure 90-120 lbs. Air Pressure 80-125 lbs.

Telegraph Name	Cylinders, Inches: Diameters: Dup. Steam	L.P. Air Cylinder	H.P. Air Cylinder	Stroke	R.P.M.	Piston Disp. Cu. Ft. Min.	I.H.P. in Steam Cylinder at Air Pressure Given: Minimum	Standard	Maximum	Floor Space Feet and Inches: Length Close Coupled	Length, Pist. Rod Coupling	Width	Height
HIGH DUTY							90 lbs.	110 lbs.	125 lbs.				
Ocrow...	16	25¼	15¼	24	110 134	1412 1722	228 278	252 307	268 327	28–0	31–6	13–3	9– 6
Ocsat....	18	28¼	17¼	27	100 125	1814 2262	290 362	320 399	341 426	30–3	33–9	14–3	9–11
Ocsox ...	20	31¼	19¼	30	95 120	2300 2920	367 465	407 517	430 544	32–6	36–0	14–9	11– 6
Ocsuy...	22	35¼	21¼	36	80 100	3024 3780	476 595	530 662	562 703	37–8	41–6	15–4	14– 0
MEDIUM DUTY							80 lbs.	90 lbs.	100 lbs.				
Octav ...	16	27¼	16¼	24	110 134	1641 2000	252 305	264 322	280 342	28–0	31–6	13–3	9– 6
Octuz ...	18	30¼	18¼	27	100 125	2070 2588	312 390	330 412	348 438	30–3	33–9	14–3	9–11
Ocumy..	20	33¼	20¼	30	95 120	2641 3336	398 505	421 531	444 562	32–6	36–0	14–9	11– 6
Ocvex...	22	37¼	22¼	36	80 100	3370 4206	502 627	532 665	561 703	37–8	41–6	15–4	14– 0

For Altitudes, Steam Pressure 90-120 lbs. Air Pressure 90-115 lbs

Telegraph Name	Dup. Steam	L.P. Air Cylinder	H.P. Air Cylinder	Stroke	R.P.M.	Piston Disp. Cu. Ft. Min.	Minimum	Standard	Maximum	Length Close Coupled	Length, Pist. Rod Coupling	Width	Height
5000 FEET							90 lbs.	100 lbs.	115 lbs.				
Ocwey...	16	27¼	15¼	24	110 134	1641 2000	244 296	255 310	272 331	28–0	31–6	13–3	9– 6
Ocwob ..	18	30¼	17¼	27	100 125	2070 2588	306 380	317 396	339 425	30–3	33–9	14–3	9–11
Ocyaz...	20	33¼	19¼	30	95 120	2641 3336	386 487	404 510	433 546	32–6	36–0	14–9	11– 6
Ocyod...	22	37¼	21¼	36	80 100	3370 4206	487 610	510 637	546 683	37–8	41–6	15–4	14– 0
10,000 FEET							90 lbs.	100 lbs.	110 lbs.				
Odarb..	16	28¼	15¼	24	110 134	1774 2161	236 287	248 302	259 315	28–0	31–6	13–3	9– 6
Odbag...	18	32¼	17¼	27	100 125	2377 2971	320 390	327 410	345 428	30–3	33–9	14–3	9–11
Odbok ..	20	35¼	19¼	30	95 120	2997 3786	398 502	418 522	435 550	32–6	36–0	14–9	11– 6
Odcum...	22	39¼	21¼	36	80 100	3763 4704	495 619	514 641	540 675	37–8	41–6	15–4	14– 0

COMPOUND AND LOW PRESSURE DUPLEX STEAM CYLINDERS FOR CLASS "OC" COMPRESSORS

Standard Duplex Cylinders	Equivalent Compound Steam Cylinders: Condensing: *Telegraph Name	Diam. H.P. Cylinder, Inches	Diam. L.P. Cylinder, Inches	Non-Condensing: *Telegraph Name	Diam. H.P. Cylinder, Inches	Diam. L.P. Cylinder, Inches	Equivalent Duplex Steam Cylinders: *Telegraph Name	Diameter, Inches
	100–120 LBS. STEAM PRESSURE			110–120 LBS. STEAM PRESSURE			70–90 LBS. STEAM PRES	
16 x 24	Sitib..........	18	30	Smort.........	19	30	Sojug.........	18
18 x 27	Sizig..........	20	34	Smucc.........	21	34	Solab.........	20
20 x 30	Slegh..........	22	38	Smuov.........	24	38	Solev.........	22
22 x 36	Slipp..........	24	40	Smuss.........	28	40	Solig.........	24
	125–150 LBS. STEAM PRESSURE			125–150 LBS. STEAM PRESSURE				
16 x 24	Slont..........	16	30	Snebb.........	17	28		
18 x 27	Slorp..........	18	34	Soalh.........	19	32		
20 x 30	Slubb..........	20	38	Sobaj.........	21	36		
22 x 36	Slugg..........	22	40	Soceg.........	24	40		
	155–180 LBS. STEAM PRESSURE			155–180 LBS. STEAM PRESSURE				
16 x 24	Smagh.........	14	30	Socot.........	15	28		
18 x 27	Smald.........	16	34	Soerg.........	17	32		
20 x 30	Smanz.........	18	38	Soezm.........	19	36		
22 x 36	Smarg.........	19	40	Sofoc.........	22	40		

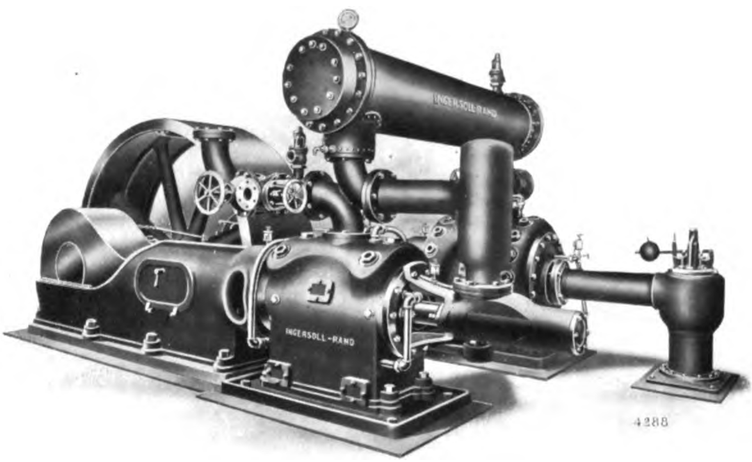
* These code words to be suffixed to code words for "O-1" and "O-2" Compressors to specify compressor with compound steam cylinders or with low pressure duplex steam cylinders.

GRIFFITH-STILLINGS PRESS 368 CONGRESS ST., BOSTON

CLASS "PB"
DUPLEX POWER DRIVEN
AIR COMPRESSORS

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

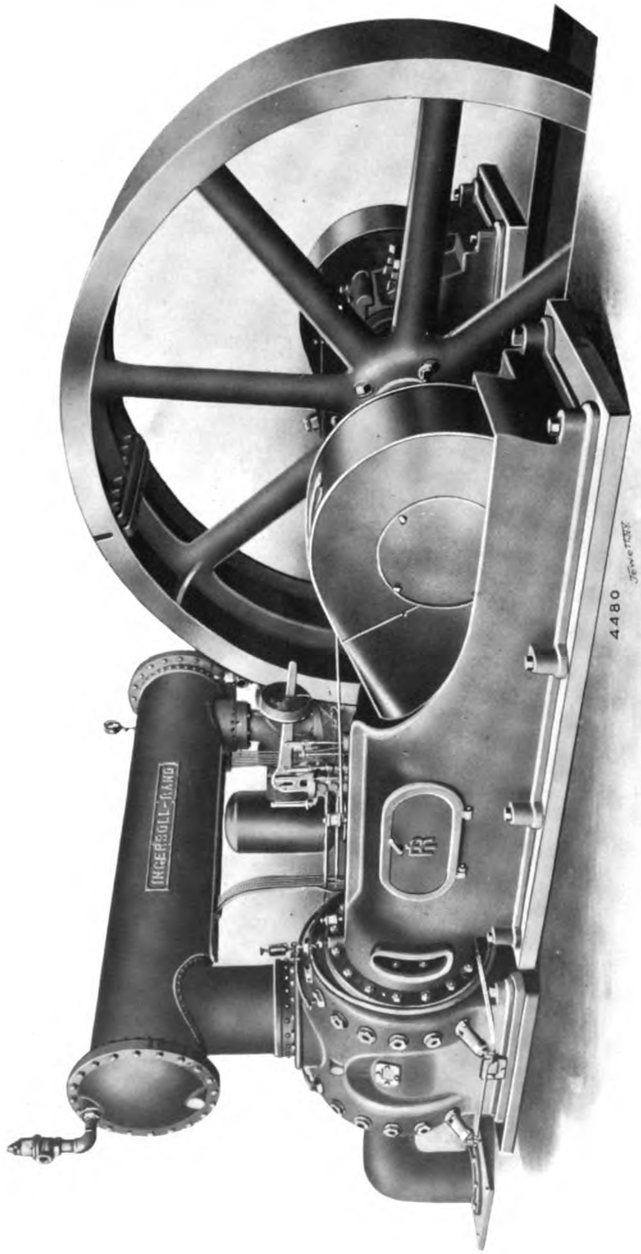
Form No. 3007 November, 1910



Class "PB-2" Compressor with Cross-Compound Air Cylinder, Intercooler and Choking Intake Controller

A PERIOD of about forty years covers practically the entire history of the development of compressed air as a power; while only the past decade may be said to have witnessed the attainment of the commercial importance which compressed air merits. These last ten years have been wonderfully fruitful of improvements in pneumatic practise. But the trend of this development has been rather in the direction of improvements in details than in the development of entirely new machines.

Particularly is this found to be true when the air compressor—the fundamental basis of any compressed air system—is studied. New valve movements and valve designs, improved cooling devices, advances along the line of mechanical design, have brought the modern air compressor to a degree of economy and reliability hardly dreamed of fifteen or twenty years ago.



Class "PB-2" Compressor with Cross-Compound Air Cylinder, Overhead Intercooler and Automatic Clearance Controller

It has remained for the Ingersoll-Rand Company, the pioneer compressor builders of the world, to produce the first air compressors in which all of the latest improvements have been combined in a machine of distinctly modern design. In the large, straight line type, the Class "AA" steam driven, and the Class "BB" power driven, are such machines. In the duplex type the Class "O" Meyer valve steam driven, and the Class "OC" Corliss steam driven, have established new standards of steam driven construction. These four types are covered by separate pamphlets.

The present pamphlet is devoted to the Class "PB" power driven compressor, which marks an advanced position in machines of this class which has never hitherto been reached. The Class "PB," the subject of this pamphlet, is designed for belt or rope drive. The same general type, however, is offered in the Class "PE" compressor, to which a separate pamphlet is devoted and which differs from the "PB" machine in having a direct-connected motor on its shaft.

General Type

The page illustration opposite gives a more clear idea of the Class "PB" compressor than any description can convey. It is of the familiar duplex type, with the air cylinders, close coupled to the frame and a central driving wheel.

In compound air types the intercooler is transverse and above the cylinders. Frames are fully enclosed and a flood lubrication system is provided. Sole-plates are placed under both air cylinders. The distinctive features of the Class "PB" design are its massive, powerful construction and its simplicity. It is marked by a rugged strength, ample reserve power, and unlimited capacity for hard work.

Simplicity

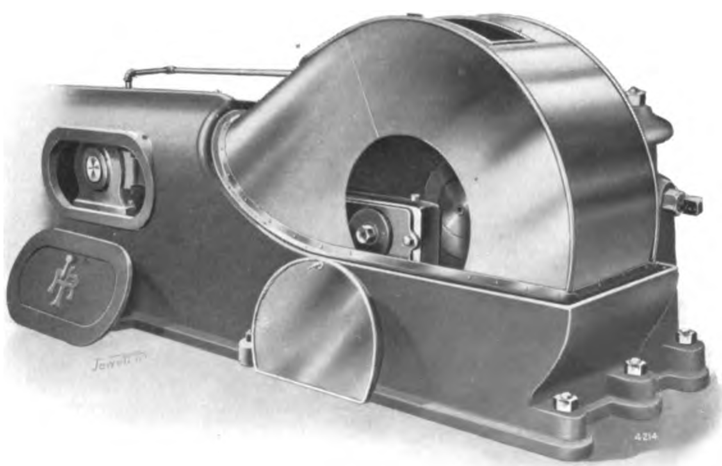
As compared with the straight line type, the duplex compressor has generally and wrongly been considered a rather complex machine, to be used only where constant attention and the best of skilled attendance could be given it. The design of the Class "PB" compressor, however, is marked by a simplicity fairly comparable with that of the "old reliable" straight line. It is a duplex compressor divested of all possible trouble-making elements, with inlet and discharge valves automatic at all speeds and pressures, requiring no setting or adjusting. It can be entrusted with the most arduous duty without fear of a breakdown or loss of efficiency.

Automatic Features

Second in importance only to simplicity, as related to operating conditions in the modern power plant, is the question of automatic action. Class "PB" compressors are as completely automatic in action as it is possible to make a high-grade compressor. The "personal equation" of the attendant must always enter in some degree into the operation of a high-duty machine; but in this new type this element has been reduced to the minimum. Automatic control of pressure, and regulation of output to load, are provided by splendid governing devices. The lubrication system, fully described later, is almost infallible and proportions the oil supply to the speed. The air valves simply take care of themselves.

Accessibility

The Class "PB" machine is accessible inside and out. At one end are the main bearings, easily reached. On the sides are the cranks, crossheads, and connecting rods, accessible while the machine is in operation through the front and top doors on the oil guards and through the large door on the side of the main frame. Air pistons can be withdrawn at the back. The main bearing boxes can be removed or renewed without taking out the shaft.



Oil Guard over Crank of Class "PB" Compressors, Showing Oil Doors in Guard and Frame, and the Enclosed Construction

Cleanliness

The enclosed construction over the cranks and around the crossheads absolutely prevents the throwing of oil from these parts. Double-grooved oil rings on the shaft prevent the escape of oil at this point. The sole-plates beneath the air cylinders have rims preventing oil or water from running over the foundation.

Adaptability

The Class "PB" air cylinders may be simple duplex or cross-compound two stage, adapted for a wide range of air pressures. There is almost no combination of requirements, except a demand for very high air pressures, which cannot be satisfied in standard machines of this class. High pressure machines in this type can be furnished, but are of special construction.

Ease of Installation

The Class "PB" compressor has all the ease of installation which has hitherto characterized only machines of the bed-plate type. Frames and cylinders come together with a boss-and-counterbore joint. A surfaced joint is provided between the sole-plates and the cylinder foot-pieces. The tie-piece uniting the main frames in certain sizes as designated later has its correct position determined in assembling by dowel pins.

The shaft cannot be mounted out of line because planed surfaces on the main bearing boxes must coincide with planed surfaces in the main bearing jaws. Planed surfaces on top of main frames serve as leveling strips in setting up the machine.

The foundation is of a type easily built, and the foundation bolts are so disposed as to be easily spaced in their correct relation in building the foundation, and readily accessible. While the Class "PB" compressor is practically a solid unit when installed, yet it breaks up into parts handled with ease and convenience for transportation, for working in close quarters, for passing through restricted openings, or for placing on the foundation.

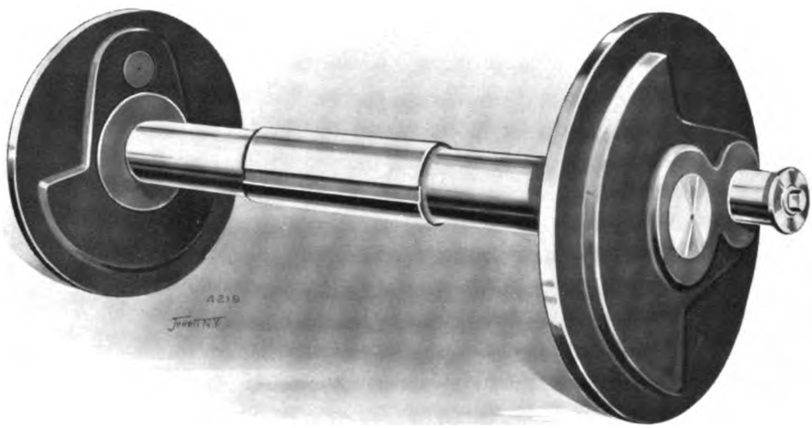
Duplex Characteristics

All of the recognized advantages of the duplex construction are embodied in Class "PB" compressors: the balanced construction with quartered cranks effecting an equalization of impulses; the reduction of operating stresses by this balanced construction; the ease with which the air cylinders can be compounded, securing the attendant compound economies without an

increased number of parts. It has already been seen that, in addition to these advantages, the Class "PB" possesses the solid, self-contained features of the straight line or of the bed-plate type of compressor. There can be no doubt that the duplex construction is the best for large, high-duty machines; and the Class "PB" compressor reveals the duplex power driven type at its very best.

The Oiling System

The usual complement of high-grade sight-feed oilers, oil cups, lubricators, etc., is provided for the lubrication of cylinders and stuffing boxes. All other bearings, however, are supplied with oil by a "flood" system



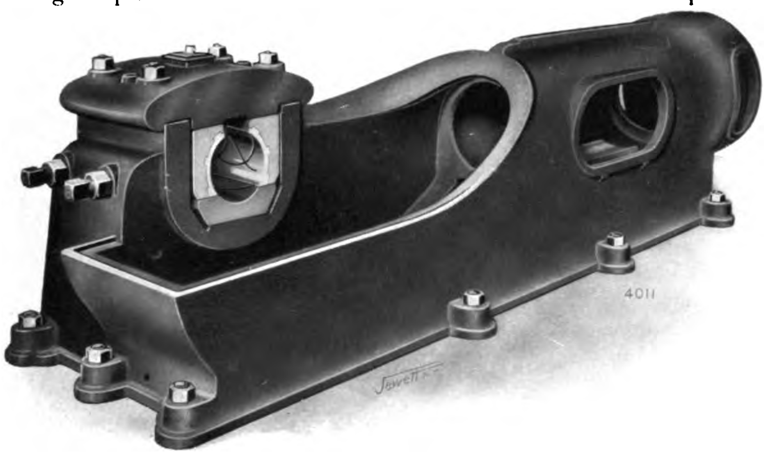
Cranks and Main Shaft of "PB" Compressor

which this Company originated and developed to the only successful working basis. In the main frame is an oil basin with a quantity of oil into which the crank disks dip. In operation a small quantity of this oil is carried up on the edge of the disks and caught at the top in a wiper which discharges it to a small pan or tank. Oil pipes lead from this pan to the main bearings, crank and crosshead pins, crosshead guides and piston rods. Glass oil cups are set on the main bearings and on the crosshead guides through which the oil from the central system flows, thus showing the engineer at all times that the machine is getting an adequate supply of oil in these vital bearings. The flow of oil begins the moment the machine starts; its delivery is proportioned at all times to the speed of the compressor; it ceases automatically when the machine stops. Arrangements are such that the oil flowing through

the bearings is returned to the crank basin to be used again and again with little loss. The economy of engine lubricant which this system affords is evident, as is also the perfect simplicity and entire adequacy of this method of oiling. It is to be particularly noted that this is a "flood," not a "splash" system of lubrication, so that there can be no uncertainty as to its operation. A web in the main frame casting, with an auxiliary stuffing box, prevents the escape of oil, while giving access to the stuffing boxes.

Main Frames

A glance at the main frame of the Class "PB" compressor immediately suggests the powerful rolling mill engine which is probably subjected to heavier duty than any other engine. This part is, in fact, modeled after rolling mill practise and is the most massive frame ever used on a compressor.



A Main Frame of a Class "PB" Compressor, with one Main Bearing Complete

It is supported under its entire length on the foundation. It is ribbed and reinforced in the best manner and is as strong as it is possible to make a solid casting. The rim or wall carried around the crank section forms the oil basin for the lubricating system. The door on the side of the crosshead section can be opened for inspection with little effort.

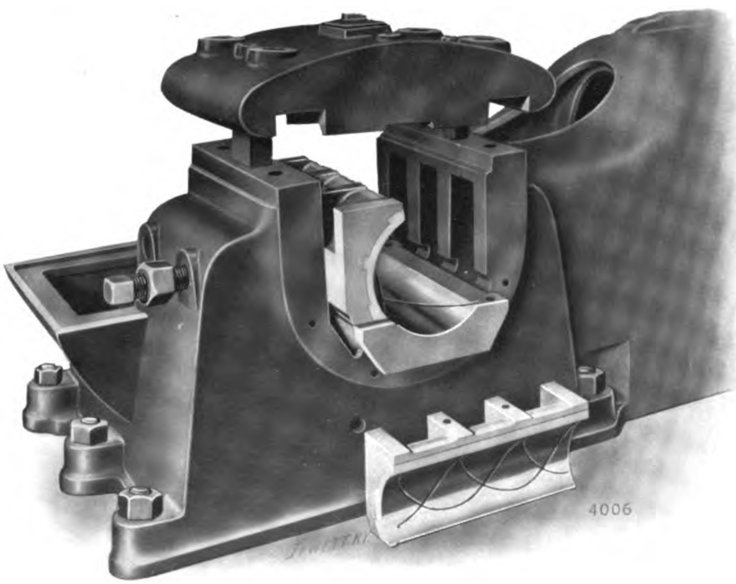
Main Frame Tie-Pieces

On machines of 24-inch stroke and smaller, a heavily ribbed cast iron tie-piece unites the two main frames, giving substantially a one-piece construction. This tie-piece is bolted on planed surfaces to each main frame and after proper alignment has been secured on the floor-plate of the erecting shop, holes are bored and dowel pins inserted so that the proper adjustment

cannot be lost in again assembling. In sizes larger than 24-inch stroke, the main frames alone give all the strength and rigidity required. Where sizes ordinarily furnished with the tie-piece are to be fitted with a driving wheel of unusually large diameter, the tie-piece is simply omitted without making any change in any other parts.

Main Bearings

The illustration here shows the massive strength of the main bearing jaws and the arrangement of the boxes. It is almost impossible to conceive of any breakage or springing of these vital parts. Planed surface on the three journal boxes normally coincide with planed surfaces in the bearing and cap. Locked bolts through the outer jaw give lateral adjustment, while cap bolts hold all in place. When necessary to inspect or renew the boxes, the shaft is lifted by a jack, just enough to remove pressure. The side adjusting bolts are loosened, the cap having been previously removed. The side boxes can now be turned and lifted out. By sliding the oil rings along the shaft, the bottom box can be drawn out until the ribs on box and bearing

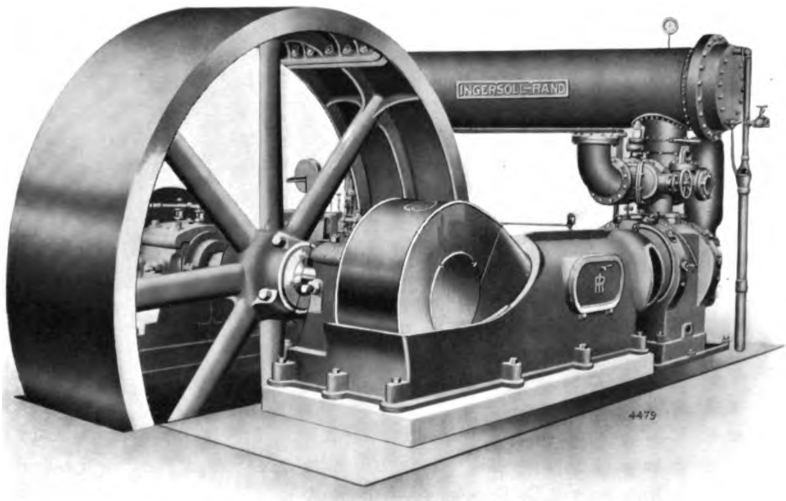


Class "PB" Main Bearing, Partly Disassembled, Showing Method of Withdrawing Boxes

clear, when the box is turned up around the shaft and removed. The side boxes proper are cast with dovetails and heavily babbitted; the bottom boxes are of phosphor bronze.

The Driving End

The standard Class "PB" compressor has a driving wheel for belt drive. The proportions of this wheel are carefully worked out to give the right width and belt contact without undue tension and strain on bearings. Where especially ordered, a rope wheel will be substituted for a belt wheel, the number of ropes and section of the rope grooves being designed for the highest efficiency. In all cases the requisite weight is provided in the driving wheel to give a fly-wheel effect adequate for the best operation.



Driving Wheel End View of Class "PB-2" Compressor

Sole-Plates

A sole-plate is under each air cylinder, having a rim which catches oil or water and prevents its escape over the foundation. Both cylinders are secured to this sole-plate by cap bolts and can be removed without loosening foundation bolts or losing alignment of parts.

The Air End

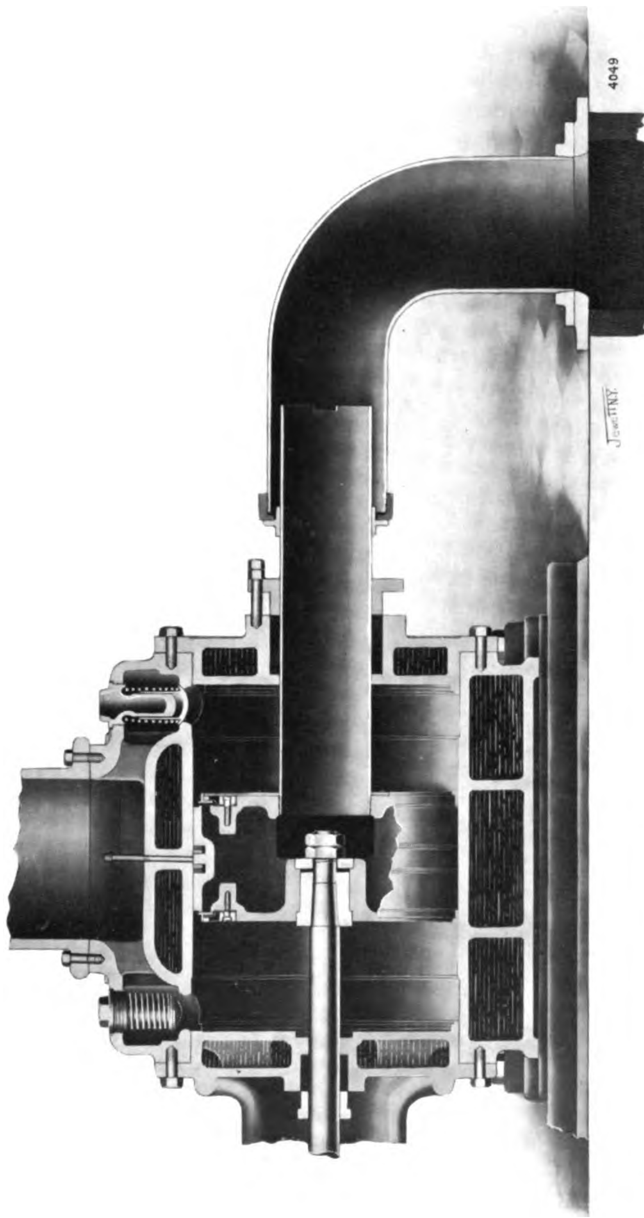
The massive design of the air end on Class "PB" compressors corresponds with the distinct, heavy-duty character of the machine as a whole. Metal is generously but judiciously used, the air cylinders being supported for their full length on the sole-plates. The cylinders are made with a full

box construction underneath, instead of a foot, the entire box being a part of the water jacket and serving as a settling chamber. Where it is impossible to get clean water for jacket cooling, this settling chamber prevents the jacket space from filling up with mud or scale and maintains the efficiency of the jacket cooling. As there are no valves in the air heads, the latter are completely water jacketed. As the head jacket is the most effective part of the jacket system, because the air in the cylinder is in contact with the head throughout the entire stroke, jacketing of this important part is kept in its most efficient form by a system of water circulation which forces the coolest water through both air heads before going to the cylinder jacket. The water enters the bottom of each head and flows out at the top, being piped from there to the bottom of each end of the cylinder. There is a single water discharge on the side of the cylinder at the top of the water space, this being piped into an open funnel connected with a drain pocket cast on the cylinder sole-plate. Thus the flow of water is always visible and can be regulated properly. There is a large drain valve for the cylinder jacket and a single drain valve on both heads and for the water piping, all of these drains being piped direct to the main cylinder drain. All of this water and drain piping is attached to the cylinder as a regular part of the machine equipment. Large hand-holes with bolted covers are provided at the top and bottom of the cylinder, and jacket plugs are provided on the heads, so that all water spaces can be easily cleaned.

The air discharge passages are exceptionally large and free, the low pressure discharge being more than one-half the area of the low pressure cylinder. This not only gives the air a free passage as soon as it leaves the valves, but also adds additional receiver space to the intercooler. The discharge valves are arranged radially in the cylinder barrel. They are of large size and the removal of one or two admits of inspection of the interior of the cylinder. Particular attention is called, in the sectional illustration on the following page, to the exceptionally complete jacketing of the cylinder and to the unusually generous provision made for admitting and discharging the air freely.

The Air Valves

The air inlet valves are of the standard "Hurricane-Inlet" pattern. Air discharge valves are of Ingersoll "Cushioned-Direct Lift" type. As both of these valves are described in detail in pamphlet No. 3001, no further discussion of them will be presented here. One point only will be emphasized, viz., the unusually large inlet and discharge valve and port areas provided in the Class "PB" type.

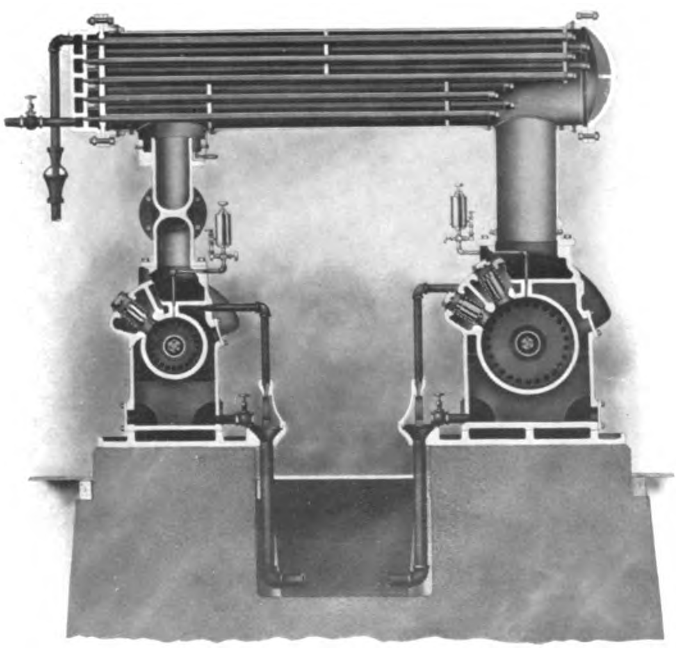


Longitudinal Section through the Air Cylinder of Class "PB" Compressors, Showing Water Jackets on Heads and Barrel, "Hurricane-Inlet" Valves, "Cushioned-Direct Lift" Discharge Valves, the Atmospheric Intake, and Large Air Passages

The very important bearing which the design of these valves and ports has on the economy and capacity of these compressors is explained more fully in the discussion of volumetric and compression efficiency on pages 15 and 16 of this pamphlet. The actual areas in any particular machine will be furnished on request. THE COMPANY INVITES A COMPARISON OF THE INLET AND DISCHARGE VALVE AREAS OF CLASS "PB" COMPRESSORS WITH THOSE OF ANY OTHER COMPRESSOR ON THE MARKET.

The Intercooler

The intercooler in two-stage types is set transversely above the air cylinders, supported by heavy cast cylinder connections. A glance at any of the illustrations of the complete machine will show the unusually large size of the intercooler which gives a very liberal cooling area, large cross-section, correct velocity of the air in transit, ample receiver capacity, and the best possible cooling economy. Pockets with drains provide for the removal of condensed moisture. Cooling water circulates through galvanized tubes which can be removed bodily from the intercooler shell. This is a very



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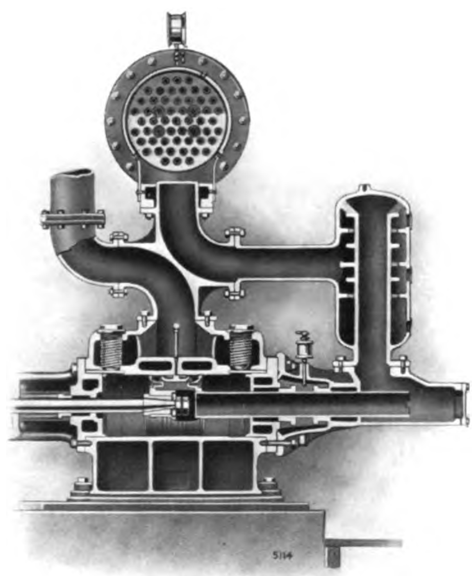
Transverse Section through Air Cylinders and Intercooler of Class "PB-2" Air Compressors

important feature, as it allows the nest of tubes to be removed for cleaning on the outside, which is frequently necessary if the compressor is so placed that it cannot take in clean air. It is also a great convenience if any repairs on the cooler are called for. Baffle plates produce repeated transverse movement of the air over the tubes. The tubes, being free at one end and independent of the shell, can expand and contract without causing any leakage. The location of the air discharge pipe coming out above the high pressure cylinder is worthy of note as compared with those constructions in which it must be carried out below the floor, with special provision in the foundation.

Water Separator

A large water separator or moisture trap is placed on the discharge pipe of the intercooler on "PB-2" compressors of 21-inch stroke and larger, through which all air, after cooling, must pass. This consists of two concentric cylinders, with over-lapping lips, between which the air passes. Entrained moisture is caught on the surface of the inner cylinder and lips and drains to the chamber in the bottom of the separator, where a drain cock is provided for its removal. This is a great improvement, resulting in the delivery of practically dry air to the high pressure cylinder.



Section Showing Construction of Water Separator

Mechanical Efficiency

High mechanical efficiency in any compressor, which is the percentage of power available for useful work after the machine friction has been overcome, depends upon four things, viz.: upon the best of workmanship throughout; upon the maintenance of true alignment, thus avoiding cramped bear-

ings; upon the adequate lubrication of all bearings; and upon the provision of generous bearing surfaces, so that bearing pressures are moderate.

The workmanship of Class "PB" compressors is of the standard Ingersoll-Rand quality, which means that it is the best which can be had. The care in enforcing alignment in Class "PB" compressors has already been emphasized. This particular element in mechanical efficiency is in these machines still further assured by the massive construction which utterly prohibits any "springing" of the structure under the most severe load conditions. The method by which the lubrication problem is solved in these compressors is described in a previous section. Only the fourth element, therefore, entering into mechanical efficiency remains to be discussed.

Beginning with the main shaft bearings, the length and diameter of these have been increased beyond all previous compressor practise. The same may be said of crank and crosshead pin bearings and crosshead guide surfaces. The air pistons are of the generous width which has long characterized all of this Company's machines. All stuffing boxes are long, so as to give an air-tight working joint without a heavy gland pressure and without undue friction on the rods and inlet tubes. Examination of the construction of Class "PB" compressors will result in a conviction that friction loss has been reduced in these machines to the practical minimum.

Volumetric Efficiency

The volumetric efficiency of a compressor is the ratio of the volume of free air actually admitted and compressed in the intake cylinder, or cylinders, to the piston displacement. A high volumetric efficiency demands the admission to the cylinder of the maximum volume of free air as cool and dense as possible, and the compression and discharge of this entire admitted volume.

Class "PB" compressors are marked by a very high volumetric efficiency, which is the result of the following features: the admission of cool, clean air through the intake connections offered; the large intake area of the "Hurricane-Inlet" valve, which is a higher percentage of the cylinder area than ordinary practise affords; the high density of the air admitted, the temperature of which cannot be perceptibly raised in entering the cylinder; the complete jacketing of the air cylinders; the jacketing of the entire air heads; and the arrangement of water circulation by which the coldest water passes through the heads first; the large area and direct passages afforded by the "Cushioned-Direct Lift" discharge valves which release the air freely; the exclusion of all air compressed, by the latter valves; the low percentage of clearance; and the sustained tightness of working parts, due

to the splendid workmanship, to the generous bearing surfaces, and to the complete lubrication provided.

Large Capacity

This high volumetric efficiency, combined with the high rotative speed of Class "PB" compressors, gives them a very large compressed air capacity considering the floor space which they require. The speeds at which these machines are run would have been deemed prohibitive a few years ago. But the heavy structure, the large bearings, the unsurpassed oiling system, the improved valve movements, and the large valve and cooling areas make these speeds entirely safe and practical.

Compression Efficiency

Compression efficiency in an air compressor is the ratio of the power theoretically required to produce a given pressure in a given volume of air, to the power actually required in the air cylinder to do this work. The modern understanding of compression efficiency is that it involves not only adequate cooling during compression, but also the discharge, with the least resistance, of the air compressed. Viewed in this light, compression efficiency is a question of getting the air into the cylinder with the least amount of work, of adequate cooling during compression, and of getting the air out of the cylinder with the least work. This understanding, therefore, presupposes large, free inlet and discharge valve areas as a primary requisite to a high compression efficiency. On a two-stage compressor an efficient intercooler is also necessary.

All of these conditions are provided for in Class "PB" compressors, as follows: by the admission of cool air through the large and well-cooled intake areas afforded by the "Hurricane-Inlet" valve; by the complete water jacketing and water circulation; by the exclusion of all heated air already compressed, by means of the superior discharge valves; by the large discharge valve areas and discharge passages; by the exceptionally large intercooler of special design, producing the maximum intercooling effect.

As both intake and discharge valves are automatic in their action and require no fixed setting or adjustment, the compression efficiency in so far as it is dependent upon these parts, is the same in Class "PB" compressors five or ten years after they have been running as when the machines are new. The natural result of all these refinements of design, which are never found in a cheap machine, is that the air card of Class "PB" compressors indicates the minimum power for compression and the maximum compression efficiency.

The True Standard of Compressor Cost

A high-grade air compressor is always to be considered in the light of an investment, not of an expense. The measure of its value should be, not its first cost, but its capacity for earning profits on its first cost.

There are three distinct features which are to be considered of the utmost importance in selecting the compressor which will be the best paying investment.

High-Grade and Durable Design, with Consequent Increased Efficiencies of Operation and Construction

Modern compressor practise has proved that high-grade, durable construction is an essential feature of the most efficient design. Liberal wearing surfaces, with a system of positive and copious lubrication, produce a marked increase in mechanical efficiency. The proper use of superior materials makes safe and practical increased speeds of operation, this alone being one of the prime essentials to a reduced first cost and a consequent saving in interest charges.

Large port and valve areas, with increased intercooling surfaces in compound types, give compression efficiencies far beyond any heretofore realized.

As both mechanical and compression efficiencies vitally affect the actual power required to compress and deliver a given volume of air at a given pressure, any increase in these efficiencies represents a direct saving in operating cost.

Low Cost of Operation and Maintenance

Both of these features are resultant factors of the high-grade design and durable construction outlined in the preceding section. Decreased power cost is in direct proportion to increased mechanical and compression efficiencies. Decreased cost of attendance, maintenance, oil, waste, etc., results from high-grade, self-contained construction. When these features are combined in a high-speed unit showing a lower first cost per cubic foot of free air compressed and delivered, the saving in interest charges on that compressor represents an additional reduction in maintenance cost.

First Cost per Cubic Foot of Free Air Compressed and Delivered

The first cost alone, of a compressor, without fair consideration of what that cost represents, is too often taken as the basis of comparison of different machines; and the purchaser is at times too apt to take a low price as a justification for buying. A true comparison of first cost must include

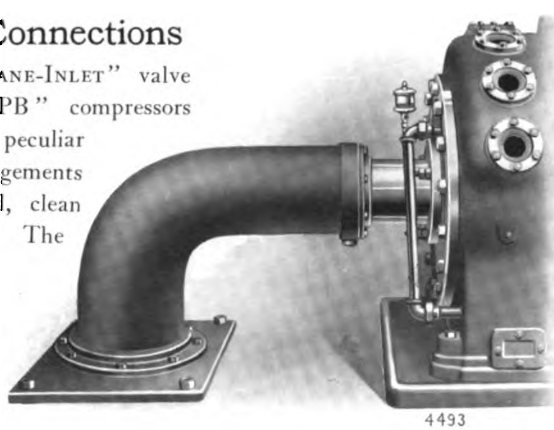
not only the first cost per cubic foot of free air per minute compressed and delivered at a stated pressure (which involves consideration of volumetric efficiency only), but also the ability to maintain high economy, as determined by the design and construction. This does not, however, give a comparative idea of the cost of operation, maintenance, etc., which remains a continued fixed charge. This latter feature is discussed in the two previous sections.

Going still further than mere first cost (which is by no means the true standard for comparison) into the problem of earning power, it is evident that that compressor is the better investment which not only has a larger assured output of compressed air, but which also, owing to its superior construction, will continue its high initial performance with the fewest delays due to shut-downs and with the least cost for repairs. Such a machine will maintain its high mechanical, volumetric, and compression efficiencies indefinitely; and even though the refinement of design and construction necessary to maintain these efficiencies may bring the first cost of that compressor higher than that of competing types, nevertheless it must be considered as the least expensive machine and its additional cost should be put down as a profitable investment, approved by good business judgment.

THE INGERSOLL-RAND COMPANY INVITES THE MOST CAREFUL COMPARISON OF CLASS "PB" COMPRESSORS WITH ANY OTHER POWER DRIVEN TYPES OFFERED TO THE TRADE, BY ANY OR ALL OF THE METHODS SUGGESTED IN THE PRECEDING PARAGRAPHS. NO EXPENSE HAS BEEN SPARED IN MAKING THESE MACHINES MEASURE UP TO THE HIGHEST STANDARDS OF COMPRESSOR VALUE.

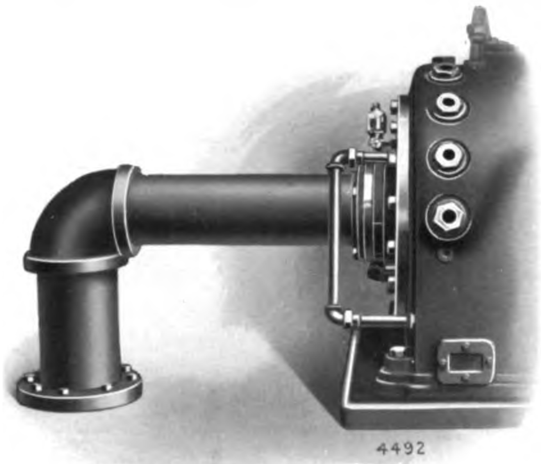
Air Intake Connections

The "HURRICANE-INLET" valve used on Class "PB" compressors lends itself with peculiar readiness to arrangements for admitting cool, clean air to the cylinder. The three following devices are offered, each of which may be connected by pipe or conduit to a suitable source of intake air.



The Standard Atmospheric Intake

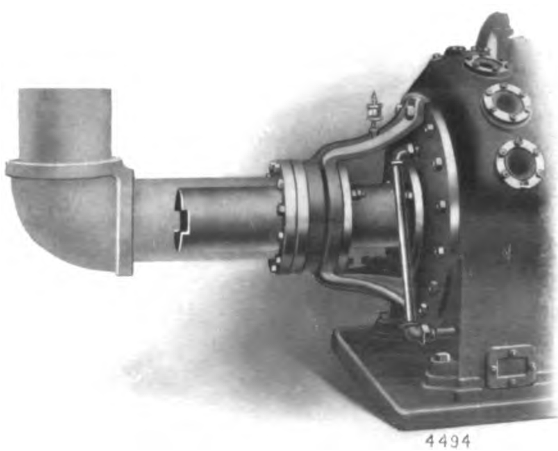
The ATMOSPHERIC INTAKE is intended for handling free air only. It is made with a cast foot-piece for bolting to floor or foundation. There is no stuffing box, but the horizontal pipe surrounding the inlet tube is closed with a brass collar just clearing the tube, giving almost an air-tight connection.



The Special Pressure or Gas Intake

The PRESSURE OR GAS INTAKE is very similar to the one just described, but the horizontal pipe is bolted over a gasket directly to the cylinder head. This is a perfectly tight intake, designed for handling any intake pressure or any vacuum. It has been developed especially for gas compression work.

The EXTENSION BRACKET is simply a casting bolted to the cylinder head, with a single stuffing box around the inlet tube in addition to the regular stuffing box in the head. The customer may connect his inlet pipe to the outer flange on the bracket. This arrangement is suitable for intake pressure up to 50 pounds, or for vacuums not exceeding four or five inches.



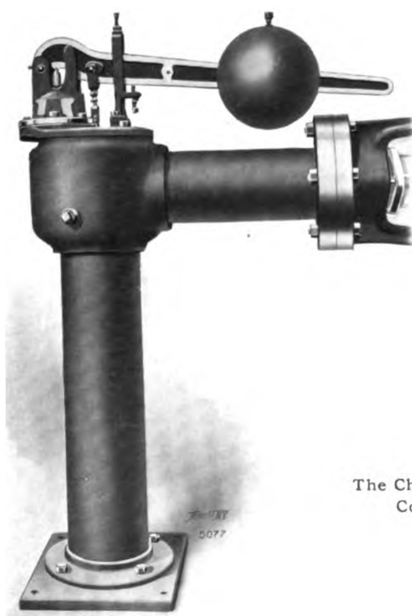
The Special Extension Bracket

The Atmospheric Intake is a part of the standard equipment of Class "PB" compressors, furnished without extra charge.

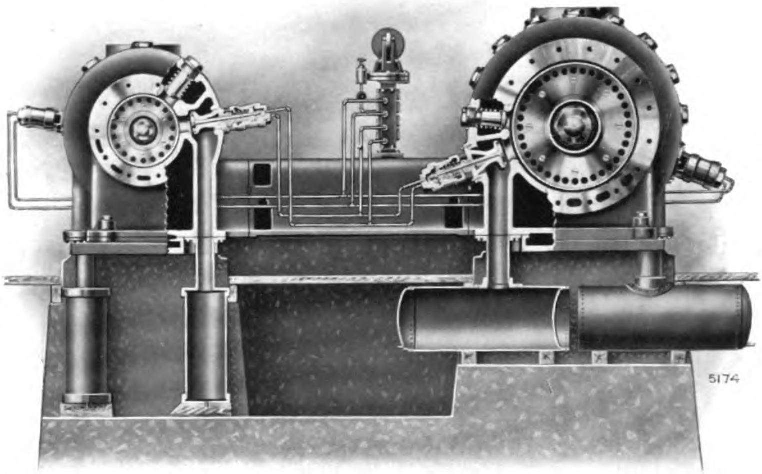
The Extension Bracket will be substituted for the Atmospheric Intake, on order, without extra cost. The Pressure Intake, however, is a special feature, furnished only on specific order, at extra cost. No intake connection is required when the machine is fitted with the Choking Intake Controller.

Regulation

The CHOKING INTAKE CONTROLLER is furnished on "PB" compressors on order. This is a throttling or choking valve placed on the compressor intake, furnishing regulation under changing load by varying the volume of air admitted and compressed. It is operated by receiver pressure moving a valve against an adjustable weight on a lever. Under normal conditions the intake is fully open. When pressure rises above normal due to a reduced demand for air, receiver pressure piped to the controller cylinder operates a valve which partially or wholly closes the compressor intake. The operation of the controller is gradual, relieving the driving mechanism of heavy shocks due to a too sudden change of load. When normal pressure has been restored, the controller weight opens the intake and free compression is resumed. The Choking Controller is entirely automatic and may be adjusted to work at any receiver pressure.



The Choking Intake Controller



The Automatic Clearance Controller as applied to the Class "PB-2" Compressor

Skip Valves can be furnished on the high pressure cylinder of compound Class "PB" compressors in connection with the Choking Intake Controller. When a two-stage machine is operating at partial load under the action of the Choking Controller on the low pressure cylinder alone, the high pressure cylinder continues to compress at full capacity. This results in a lowering of intercooler pressure and an increase in the number of compressions in the high pressure cylinder, with resulting high temperature. The adjustable Skip Valves at either end of the high pressure cylinder allow the air to by-pass automatically from this cylinder back to the intercooler when the pressure in the latter has been reduced to a predetermined point. This arrangement of Skip Valves in connection with the Choking Intake Controller keeps the temperatures of compression within safe limits under all changes of load.

The Automatic Clearance Controller is a patented device for economically regulating the capacity of Class "PB" compressors by varying the amount of clearance. It consists of a number of clearance pockets which are thrown automatically into communication with the ends of each air cylinder in proper succession, this process being controlled by a predetermined variation in receiver pressure. Regulation is obtained in five stages, viz.: full load; three-quarter load; half load; quarter load; and no load. The operation of this system of regulation is as follows: with the compressor operating at partial capacity, a portion of the air is compressed into an added

clearance space instead of passing through the discharge valves. On the return stroke this air expands, giving up its stored energy to the piston. The inlet valves remain closed until cylinder pressure equals intake pressure. The inlet valves then open automatically by a slight difference of pressure and free air is admitted to the cylinder for the remainder of the return stroke. Thus the inlet capacity of the compressor is reduced without reducing the intake pressure. On a two-stage compressor, clearance space in the proper proportion is added simultaneously to both high and low pressure cylinders, thus maintaining a constant ratio of compression throughout the entire load range and obtaining the highest compression efficiency throughout. The reduction in power secured with this method of control is practically in direct proportion to the reduction of load. This regulator is simple in construction and entirely automatic in operation.

Packing

The stuffing boxes for piston rod and inlet tubes are so designed on Class "PB"compressors as to take either plain or metallic packing, without special heads or other features. Fibrous packing is ordinarily furnished, however. Special metallic packings are furnished only on specific order, at extra cost.

General Construction

In standards of materials, workmanship, interchangeability, inspection and test, Class "PB" compressors conform with the requirements as laid down in pamphlet No. 3001, covering all Ingersoll-Rand compressors. The type is distinctly one for high duty under heavy service, offering to the trade everything that is most desirable in a reliable, high-grade, power driven compressor.

Standard Classifications

The standard Class "PB" type is offered in two different combinations of cylinders designated by the following symbols:

Class "PB–1" Duplex single-stage air cylinders.

Class "PB–2" Compound two-stage air cylinders.

Sizes and Capacities

The standard sizes and capacities of Class "PB" compressors as given in the tables on pages 22 and 23. This pamphlet is not intended to go into the minute details of construction of these machines. This latter information is set forth in the specifications which will be furnished to those asking for a quotation on a compressor to meet conditions as set forth in the request for information.

DUPLEX POWER DRIVEN AIR COMPRESSORS, CLASS "PB-2"

Cross-Compound Two-Stage Air Cylinders; Overhead Horizontal Intercoolers; Flood Lubrication

For Sea Level **Air Pressure 90 to 125 Pounds**

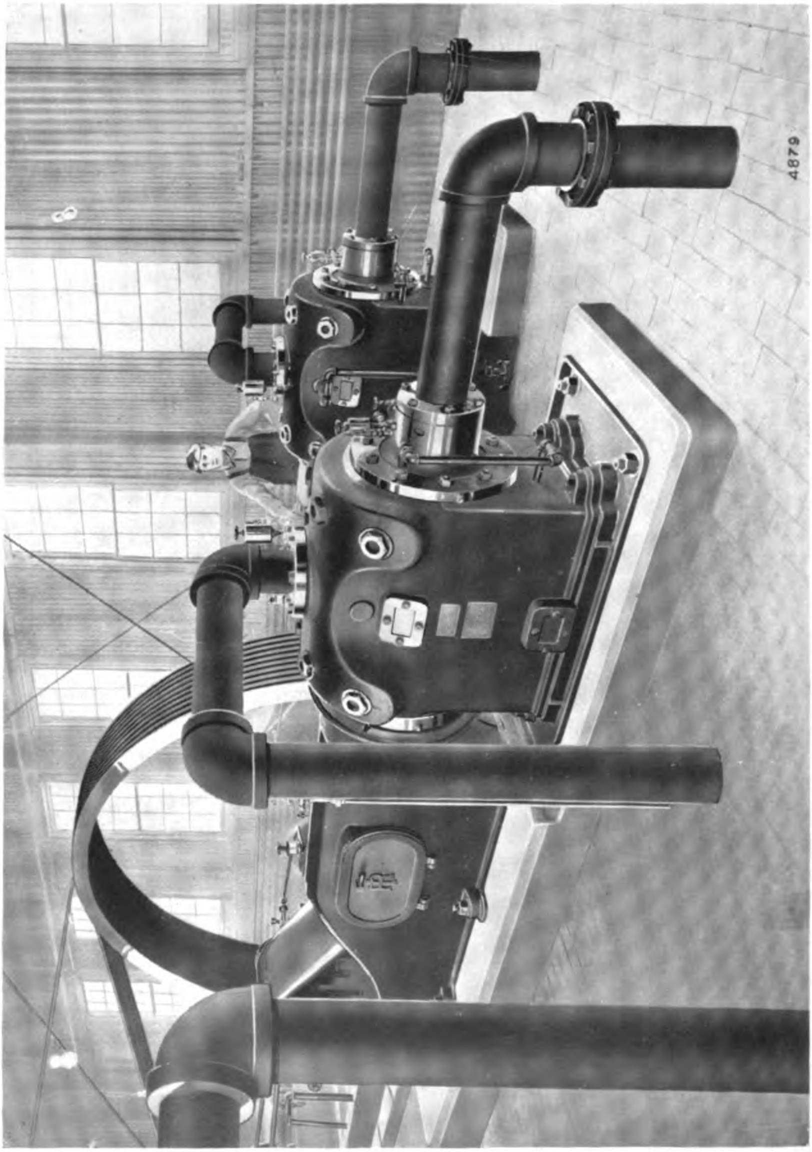
Telegraph Name	Cylinders Inches			R. P. M.	Piston Displacement Cubic Feet per Minute	B. H. P. at Belt Wheel of Compressor			Dimensions of Belt Wheel		Approximate Floor Space Feet, Inches		
	Low Pressure	High Pressure	Stroke			Minimum	Standard	Maximum	Diameter Feet Inches	Face Inches	Length	Width	Height
						Air Pressures							
						90 lbs.	110 lbs.	125 lbs.					
High Duty													
Plaby	16¼	10¼	16	200	**701**	116	127	136	7–0	15	16–10	8–10	8–0
Plamk	19¼	12¼	18	180	**997**	162	179	191	8–0	20	19–6	10–4	8–6
Plarn	22¼	13¼	21	160	**1392**	224	247	263	9–0	29	22–4	11–10	8–6
Plasp	25¼	15¼	24	140	**1802**	290	320	340	10–6	36	23–10	12–6	9–0
Plavs	28¼	17¼	27	125	**2268**	361	401	424	12–0	45	25–6	14–6	9–6
Plawt	31¼	19¼	30	115	**2830**	451	500	530	13–6	54	28–0	16–0	10–6
Plezy	35¼	21¼	36	100	**3780**	595	655	696	16–0	62	32–2	17–0	11–8
Medium Duty						**80 lbs.**	**90 lbs.**	**100 lbs.**					
Pliff	17¼	10¼	16	200	**780**	121	128	135	7–0	15	16–10	8–10	8–0
Plors	20¼	12¼	18	180	**1117**	172	182	191	8–0	20	19–6	10–4	8–6
Plost	24¼	14¼	21	160	**1650**	250	265	279	9–0	29	22–4	11–10	8–6
Ploxy	27¼	16¼	24	140	**2090**	317	335	355	10–6	36	23–10	12–6	9–0
Ployz	30¼	18¼	27	125	**2600**	391	413	435	12–0	45	25–6	14–6	9–6
Plump	33¼	20¼	30	115	**3200**	481	508	535	13–6	54	28–0	16–0	10–6
Plups	37¼	22¼	36	100	**4206**	623	660	695	16–0	62	32–2	17–0	11–8
5,000 Feet Altitude						**90 lbs.**	**100 lbs.**	**115 lbs.**					
Pojum	17¼	10¼	16	200	**781**	116	123	131	7–0	15	16–10	8–10	8–0
Pokaj	20¼	12¼	18	180	**1116**	164	173	185	8–0	20	19–6	10–4	8–6
Pokek	24¼	13¼	21	160	**1650**	240	253	269	9–0	29	22–4	11–10	8–6
Pokil	27¼	15¼	24	140	**2080**	305	321	342	10–6	36	23–10	12–6	9–0
Pokom	30¼	17¼	27	125	**2600**	374	394	421	12–0	45	25–6	14–6	9–6
Pokun	33¼	19¼	30	115	**3200**	461	485	518	13–6	54	28–0	16–0	10–6
Polak	37¼	21¼	36	100	**4206**	600	632	675	16–0	62	32–2	17–0	11–8
						70 lbs.	**80 lbs.**	**95 lbs.**					
Polel	18¼	10¼	16	200	**885**	117	125	136	7–0	15	16–10	8–10	8–0
Polim	21¼	12¼	18	180	**1216**	159	170	184	8–0	20	19–6	10–4	8–6
Polon	25¼	14¼	21	160	**1802**	233	248	270	9–0	29	22–4	11–10	8–6
Polup	28¼	16¼	24	140	**2268**	292	312	338	10–6	36	23–10	12–6	9–0
Pomal	32¼	18¼	27	125	**2973**	378	405	440	12–0	45	25–6	14–6	9–6
Pomem	35¼	20¼	30	115	**3614**	458	490	533	13–6	54	28–0	16–0	10–6
Pomin	39¼	23¼	36	100	**4704**	594	635	690	16–0	62	32–2	17–0	11–8
10,000 Feet Altitude						**90 lbs.**	**100 lbs.**	**115 lbs.**					
Pooty	18¼	10¼	16	200	**885**	119	125	133	7–0	15	16–10	8–10	8–0
Poovz	21¼	12¼	18	180	**1216**	162	169	180	8–0	20	19–6	10–4	8–6
Pooxc	25¼	13¼	21	160	**1802**	236	248	263	9–0	29	22–4	11–10	8–6
Popan	28¼	15¼	24	140	**2268**	297	312	332	10–6	36	23–10	12–6	9–0
Popep	32¼	17¼	27	125	**2974**	385	403	429	12–0	45	25–6	14–6	9–6
Popir	35¼	19¼	30	115	**3612**	468	491	523	13–6	54	28–0	16–0	10–6
Popos	39¼	21¼	36	100	**4704**	603	634	673	16–0	62	32–2	17–0	11–8
						70 lbs.	**80 lbs.**	**90 lbs.**					
Poput	19¼	10¼	16	200	**990**	118	126	133	7–0	15	16–10	8–10	8–0
Porap	22¼	12¼	18	180	**1344**	158	169	179	8–0	20	19–6	10–4	8–6
Porer	26¼	14¼	21	160	**1955**	227	243	256	9–0	29	22–4	11–10	8–6
Poris	30¼	17¼	24	140	**2572**	297	317	336	10–6	36	23–10	12–6	9–0
Porot	34¼	19¼	27	125	**3341**	383	408	432	12–0	45	25–6	14–6	9–6
Poruv	37¼	20¼	30	115	**4030**	460	492	521	13–6	54	28–0	16–0	10–6
Posar	41¼	23¼	36	100	**5190**	589	630	665	16–0	62	32–2	17–0	11–8

DUPLEX BELT DRIVEN AIR COMPRESSORS, CLASS "PB-1"

Simple Duplex Air Cylinders **Flood Lubrication**

Air Pressure, 20 to 100 Pounds

Telegraph Name	Cylinders Inches: Diameter each Duplex Air Cylinder	Cylinders Inches: Stroke	R. P. M.	Piston Displacement Cubic Feet per Minute	Air Pressure Designed For: Standard	Air Pressure Designed For: Maximum	B.H.P. Requ'ed at Belt Wheel of Compressor: Standard	B.H.P. Requ'ed at Belt Wheel of Compressor: Maximum	Stand'd Belt Wheel: Diameter Feet, Inches	Stand'd Belt Wheel: Face, Inches	Overall Dimensions Feet, Inches: Length	Overall Dimensions Feet, Inches: Width	Overall Dimensions Feet, Inches: Height
Poutz	12¼	16	200	**792**	70	80	125	137	7-0	15	16-3	8-6	5-6
Pouxd	14¼	16	200	**1081**	40	45	122	132	7-0	15	16-3	8-6	5-6
Pouzg	16¼	16	200	**1403**	25	30	118	133	7-0	15	16-3	8-6	5-6
Povat	14¼	18	180	**1090**	70	85	169	190	8-0	20	19-0	9-0	6-0
Povev	16¼	18	180	**1415**	45	55	169	192	8-0	20	19-0	9-0	6-0
Povox	18¼	18	180	**1782**	30	35	163	183	8-0	20	19-0	9-0	6-0
Povuy	20¼	18	180	**2234**	20	25	155	184	8-0	20	19-0	9-0	6-0
Powav	16¼	21	160	**1464**	80	90	241	255	9-0	29	20-6	9-10	6-8
Powew	18¼	21	160	**1843**	55	65	245	273	9-0	29	20-6	9-10	6-8
Powix	20¼	21	160	**2313**	45	50	231	273	9-0	29	20-6	9-10	6-8
Powoy	22¼	21	160	**2785**	25	30	225	256	9-0	29	20-6	9-10	6-8
Powuz	24¼	21	160	**3300**	20	25	226	269	9-0	29	20-6	9-10	6-8
Poxaw	18¼	24	140	**1838**	90	100	324	343	10-6	36	23-0	11-0	7-6
Poxex	20¼	24	140	**2308**	60	70	325	359	10-6	36	23-0	11-0	7-6
Poxoz	22¼	24	140	**2780**	45	55	324	370	10-6	36	23-0	11-0	7-6
Poxub	24¼	24	140	**3296**	35	40	332	365	10-6	36	23-0	11-0	7-6
Poyax	26¼	24	140	**3913**	25	30	316	360	10-6	36	23-0	11-0	7-6
Poyey	20¼	27	125	**2310**	90	100	403	427	12-0	45	25-6	13-0	8-6
Poyiz	22¼	27	125	**2785**	60	75	387	445	12-0	45	25-6	13-0	8-6
Poyob	24¼	27	125	**3301**	45	55	383	435	12-0	45	25-6	13-0	8-6
Poyuc	26¼	27	125	**3920**	35	40	392	430	12-0	45	25-6	13-0	8-6
Pozay	28¼	27	125	**4530**	25	30	358	408	12-0	45	25-6	13-0	8-6
Pozez	30¼	27	125	**5190**	20	25	346	413	12-0	45	25-6	13-0	8-6
Pozib	22¼	30	115	**2840**	85	100	472	518	13-6	54	28-0	14-6	9-9
Pozoc	24¼	30	115	**3375**	65	75	488	533	13-6	54	28-0	14-6	9-9
Pozud	26¼	30	115	**4000**	45	55	463	527	13-6	54	28-0	14-6	9-9
Prack	28¼	30	115	**4630**	35	45	458	541	13-6	54	28-0	14-6	9-9
Prahp	30¼	30	115	**5295**	30	35	476	524	13-6	54	28-0	14-6	9-9
Praks	32¼	30	115	**6080**	25	28	484	527	13-6	54	28-0	14-6	9-9
Pralt	24¼	36	100	**3510**	90	100	600	637	16-0	62	32-0	16-0	11-0
Prary	26¼	36	100	**4170**	75	85	655	705	16-0	62	32-0	16-0	11-0
Prayg	28¼	36	100	**4820**	55	65	622	691	16-0	62	32-0	16-0	11-0
Prehr	30¼	36	100	**5508**	45	50	637	685	16-0	62	32-0	16-0	11-0
Prejs	32¼	36	100	**6325**	35	40	617	677	16-0	62	32-0	16-0	11-0
Prekt	34¼	36	100	**7014**	30	35	630	698	16-0	62	32-0	16-0	11-0
Prenx	36¼	36	100	**8037**	25	28	635	691	16-0	62	32-0	16-0	11-0



One of the two Ingersoll-Rand Class "PB-1" Rope Driven, Simple Duplex Gas Compressors in the Pumping Station of the A. H. Heisey Glass Co., Newark, O.

AMERICAN BANK NOTE COMPANY

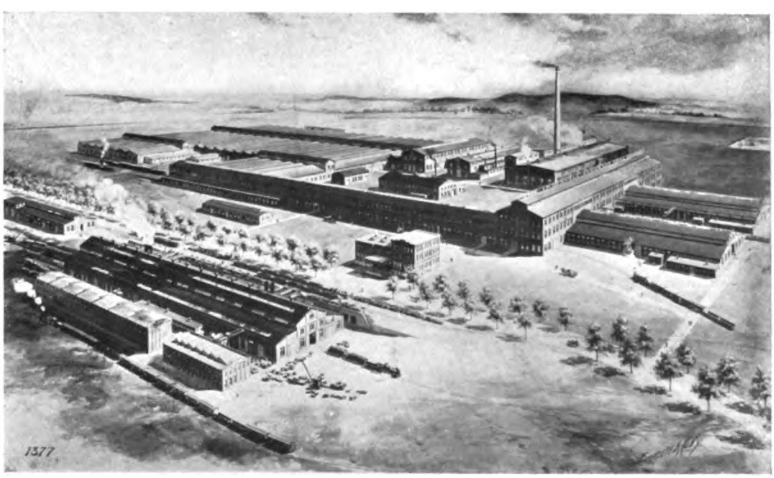
GAS COMPRESSORS

INGERSOLL–RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 3017 May, 1910

TO the problems of gas compression the Ingersoll-Rand Company brings an experience of thirty-nine years devoted to the building of air and gas compressors and pneumatic machinery. The purchaser of Ingersoll-Rand Gas Compressors, therefore, secures the benefits of this unequaled experience and is protected by the guarantees of the oldest and largest builders in the business.

While the compression of gas for transmission purposes may be said to be of comparatively recent date, yet the fundamental principles of gas compressor design are the same as those of air compressor design. Thus the purchaser of a gas compressor has reason to expect the best results from that machine which represents the best design, the widest experience and the longest record. The history of Ingersoll-Rand air compressors dates back to 1871; and the Company has been identified closely with gas compression ever since it has assumed commercial proportions. Ingersoll-Rand

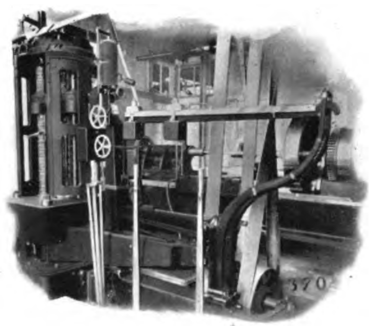


Plant of Ingersoll-Rand Co., at Phillipsburg, N.J.

Gas Compressors, therefore, may be accepted by the trade as representative of the best and most up-to-date construction, from which may be expected the best economy, the greatest endurance under heavy duty and continued satisfactory performance.

Manufacturing Methods

Ingersoll-Rand Gas Compressors are built in the largest shops in the world devoted to compressor production—shops equipped with the most up-to-date machinery, manned by a working force of specially trained mechanics, and supervised by a corps of experts. The resulting product is one of unsurpassed workmanship and quality. Raw materials are purchased under rigid specifications. Composition metals are made from special proved formulas; cast iron is of a special grade combining uniform structure, good wearing qualities, and strength. Steels of various carbon percentages are used, as experience has demonstrated their peculiar fitness for certain parts. Alloy steels are used where the engineers' judgment approves their application.



A Testing Machine in the Material Testing Department

The oil treatment of steel has been carried by the Ingersoll-Rand Company to a degree of refinement never before attained and hardly attempted by other builders. The process, which is applied to all steel parts requiring unusual staying power, is very similar to, and no less exacting than, that used by the United States Government for the treatment of ordnance forgings. Steel parts after rough machining are given this oil treatment and then go to annealing ovens where the internal stresses of cooling or forging

The Oil Treating Department, Showing Oil Tanks and Annealing Furnaces

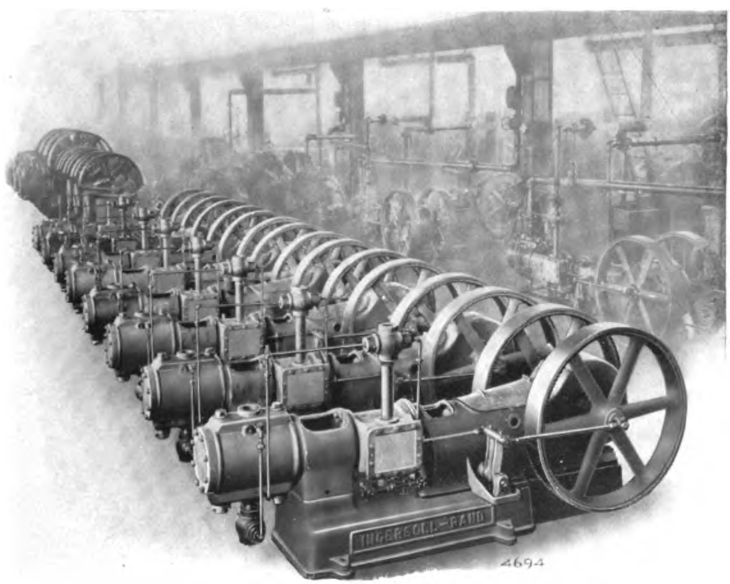
are removed. The result of this treatment is an increase of 25 to 30 per cent in the tensile strength of the parts, as well as an increase in the ductility, toughness and elastic limit of the steel.

Interchangeability and Inspection

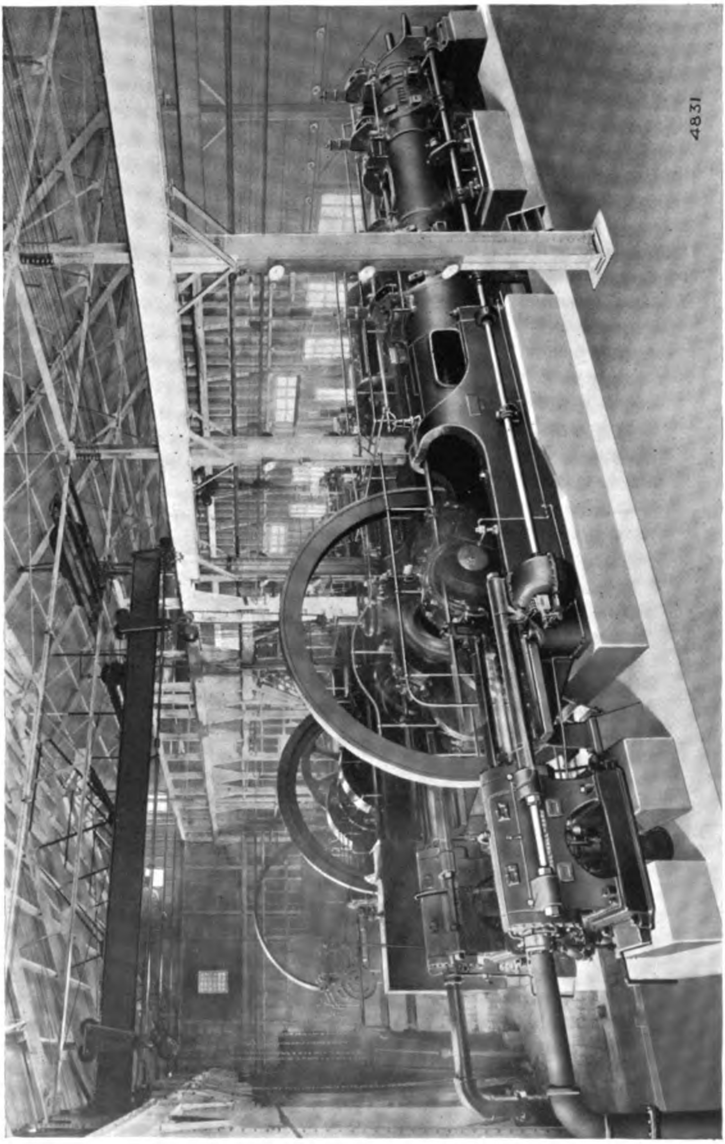
Each part of an Ingersoll-Rand Gas Compressor is individually inspected before acceptance for stock. All wearing parts subject to replacement are tested by limit gauges and must be dimensionally correct to the thousandth part of an inch. This care results in absolute interchangeability of parts, so that "parts that fit" are guaranteed, and can usually be secured immediately. Aside from this test and inspection of individual parts, each machine throughout its assembling is inspected at every stage. All adjustments are made on machines for the best operating results. It may be said that every Ingersoll-Rand Gas Compressor when it is shipped is known to be *right*. It goes to the purchaser backed by the Company's prestige and guarantees.

Compressor Types

The complete Ingersoll-Rand line of compressors includes



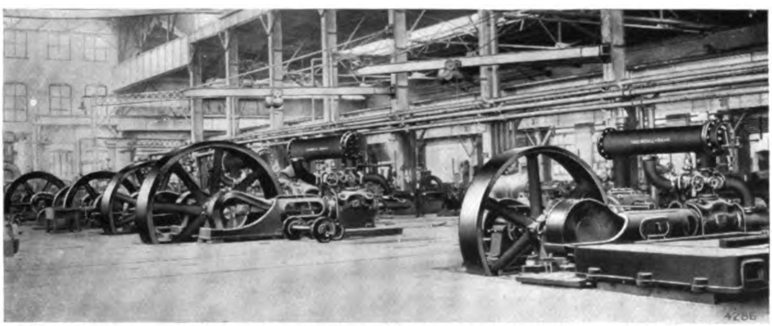
A Group of Steam Driven Compressors Complete and Ready for Stock, with Machines Under Test in the Background



Two Ingersoll-Rand-Westinghouse Gas Engine Driven Gas Compressors at the Plant of the Logan Natural Gas Co., Sugar Grove, O.

twenty distinct types, built in more than a thousand different sizes. Inasmuch, however, as the Company has standardized upon its "Hurricane-Inlet" valve or its "Direct Lift" inlet valve for gas compression work, the list of gas compressors is somewhat reduced, as it does not include those machines of Corliss inlet valve type. The gas compressor list, however, is still large and varied enough to afford a machine peculiarly adapted for almost any duty that may be encountered in gas work. Throughout the entire line, from the smallest machine to the largest, only one grade and quality is offered — *the very best.*

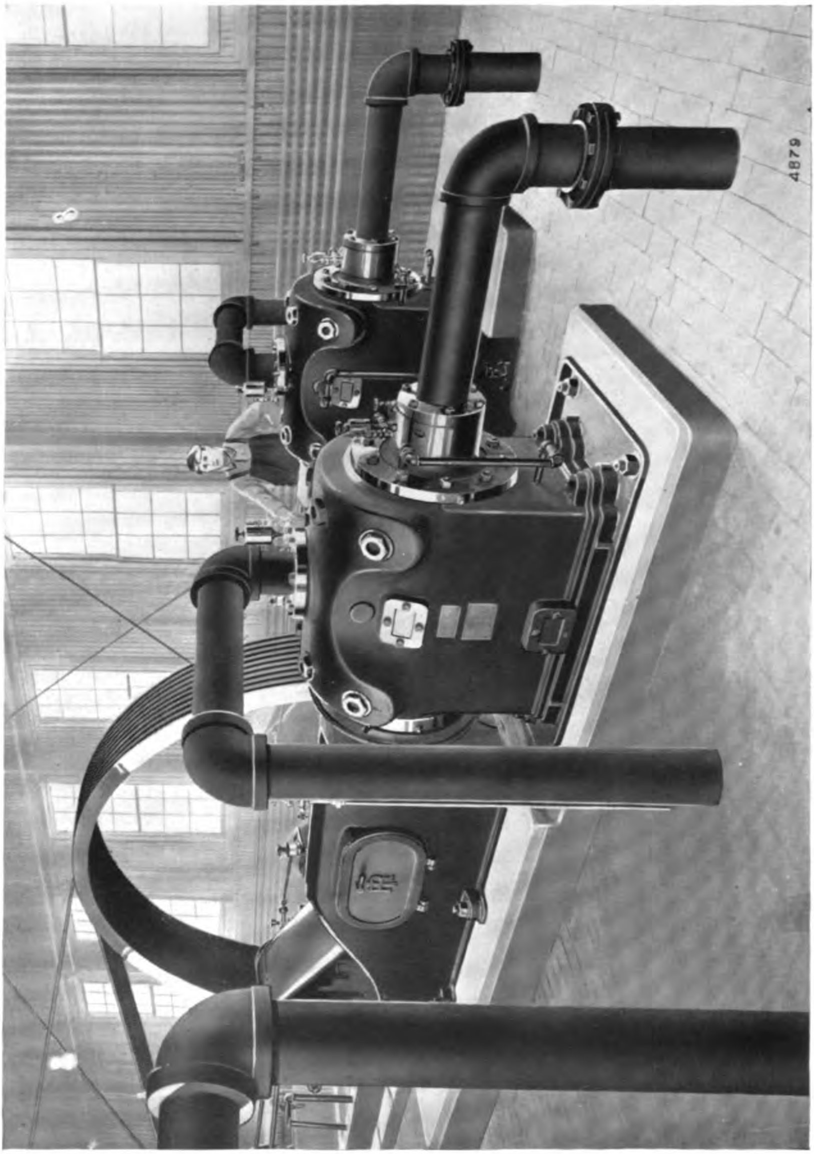
On pages 23 to 25 six compressors are illustrated which the Company recommends for gas compression work, and which afford the necessary range of capacities for nearly all conditions. Separate pamphlets on any of these machines are issued and can be had on request. In the present pamphlet attention will be given only to the more important details common to all of these machines, and of special interest to the gas trade.



The Erecting Floor and Test Pits in the Phillipsburg Shops, with Large Compressors being Erected and under Test and Inspection

Valve Movements

Nothing will lower the economy of a gas compressor more quickly than defects or shortcomings in the valve movements for the compressing end. The Company has, therefore, made a most careful study of this subject, and, as stated above, has standardized for gas compression work on the "Hurricane-Inlet" valve for medium and larger machines; on the "Direct Lift" inlet valve for small and, under certain conditions, for large machines; and on the "Cushioned Direct Lift" discharge valve for all sizes.

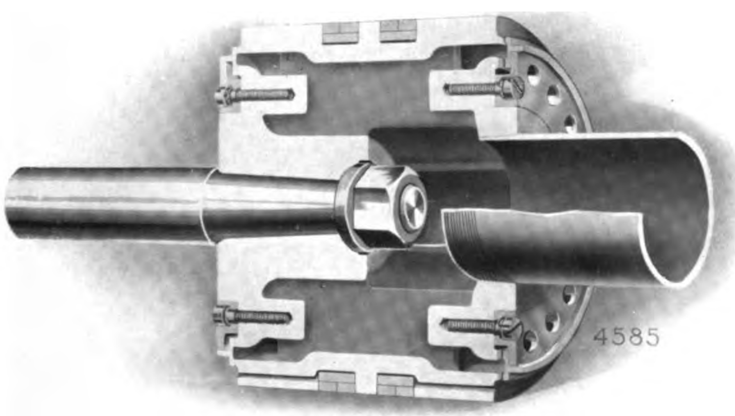


One of the Two Ingersoll-Rand class "PB" Rope Driven Gas Compressors in the Pumping Station of the A. H. Heisey Gas Co., Newark, O.

The "Hurricane-Inlet" Valve

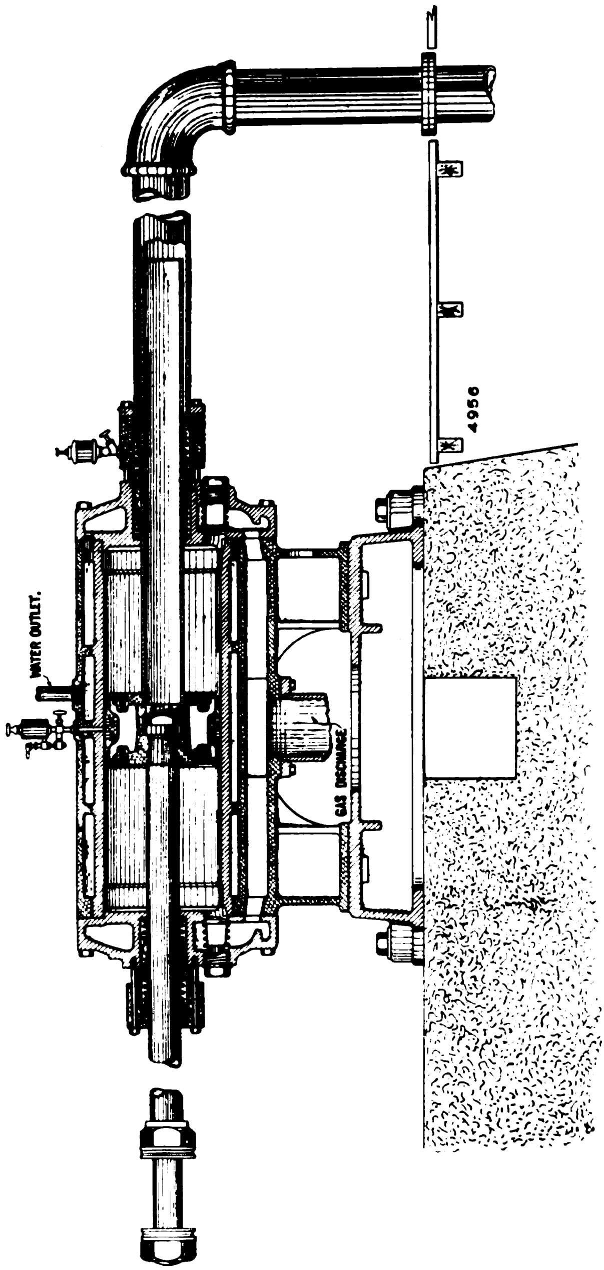
The "Hurricane-Inlet" valve is a development of the original Sergeant Piston Inlet valve, the piston inlet feature of which it retains. Most important improvements over the earlier type have, however, been incorporated in this new construction, so that it has really established a new standard of inlet valve efficiency.

No type of inlet valve lends itself so readily to the problems of gas compression as the "Hurricane-Inlet." Its intake is entirely free and clear of the machine and the foundation, making it exceptionally easy to connect up to the pipe line. The section of the "Hurricane-Inlet" gas cylinder on page 8 shows the "Gas Intake" around the inlet tube,—an arrangement specially designed for gas compression. For gas compression work, however, another style of intake connection is also offered, which is substituted on order for the "Gas Intake" as shown in the illustration above referred to. These two intake connections are described more fully later.



A Standard "Hurricane-Inlet" Valve Piston in Section

Each "Hurricane-Inlet" piston carries two ring valves, one on each face. Each valve is a simple ring of oil-treated steel, forged without welds from a solid billet and turned to a light "T" section. There are no holes, slots or weak places in the valve— simply a plain steel ring of uniform cross-section throughout. The inlet port is an annular opening in each piston face, of very large area and free from any obstruction whatever, so that its entire area is effective.



Longitudinal Section of an Ingersoll-Rand Gas Compressing Cylinder with "Hurricane-Inlet" and "Cushioned Direct Lift" Discharge Valves

Bolted to the face of the piston is a steel guide plate with a series of large openings just within its circumference. The ring valve rests loosely between the guide plate and the piston face, the bar of the "T" forming the valve face and the upright of the "T" the guide section sliding on the guide plate. The travel between guide plate and piston is the lift of the valve. The construction is identical on both faces of the piston. The two valves travel with the piston, the one in front closing by its inertia, and remaining closed under the gas pressure in advance of the piston. The other valve (assuming that this is the first stroke) drops back against its guide plate the moment the piston starts, making a full valve opening which is maintained until the piston stops, when this valve, continuing its motion, slides gently to its seat.

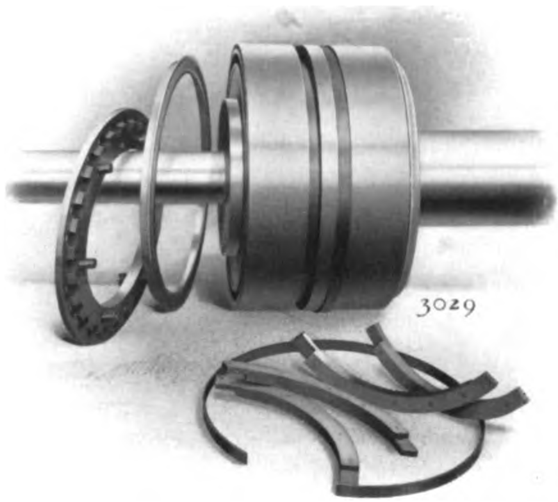
A Single "Hurricane-Inlet" Valve

On the return stroke the leading valve (which was the following valve on the forward stroke) is already closed and compression begins at once. The following valve is now held to its seat by clearance pressure until enough of the stroke has been completed to expand the clearance gas to intake pressure. This valve then drops behind the piston because of its inertia, thus fully opening and remaining open until the end of the stroke, when it closes instantly. This completes the cycle for one revolution and this cycle is repeated so long as the machine is running.

The following points are to be particularly noted as bearing upon the efficiency of the "Hurricane-Inlet" valve. There can be no escape of clearance gas, for the inlet valve cannot open until the clearance gas has expanded to intake pressure. As the valve is very light, and its lift or travel very slight, there is no shock on opening or closing, no battering, and no undue wear.

The valve is double-ported, gas entering the cylinder outside the ring valve and inside of it through the openings in the guide plate. With a very slight lift a very large inlet opening is afforded — a wide annular space almost as large in diameter as the piston and amounting to from 12 to 15 per cent of the total cylinder cross-section.

The valve movement is positive; the valves *must* open and close.



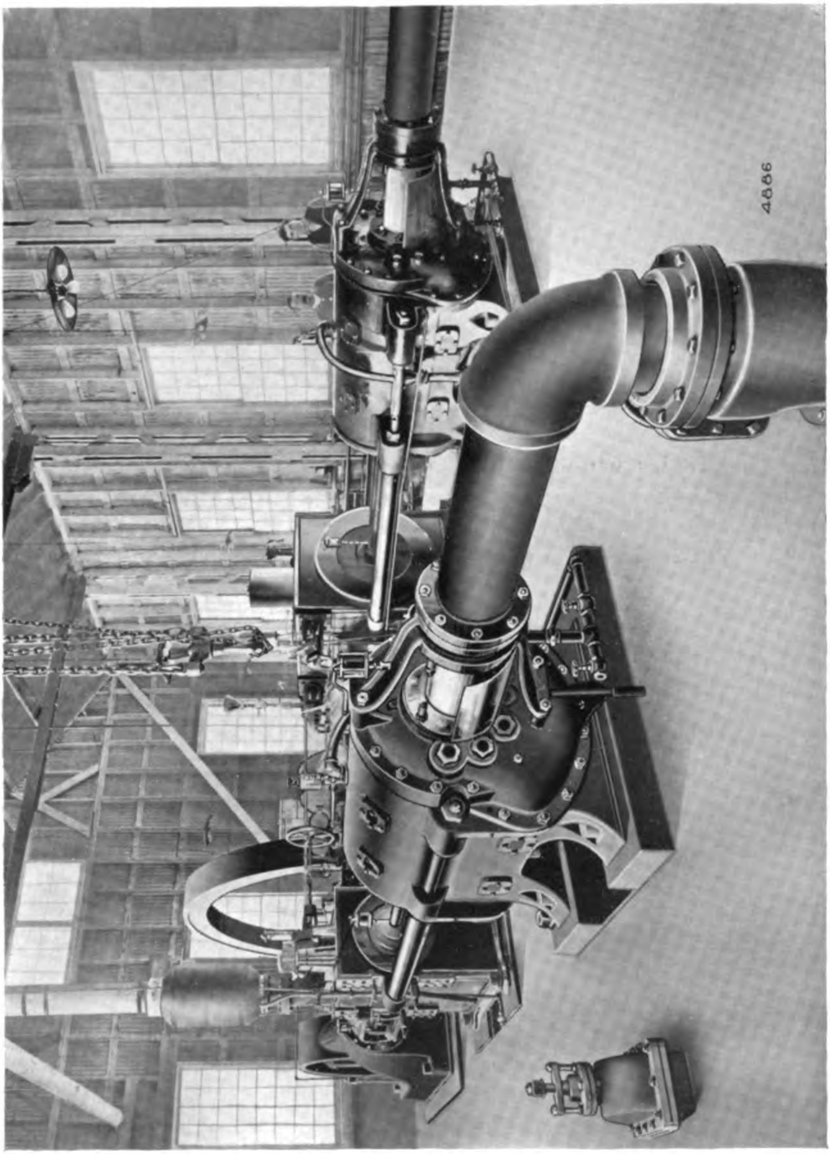
A "Hurricane-Inlet" Piston, with its Component Parts

They are literally bathed in oil from the cylinder lubricator, flowing down over the piston face. They cannot bind or stick. They are self-grinding, for it is found that the ring turns around on the guide plate and practically never seats twice in succession in the same position.

Nothing can be more simple than the "Hurricane-Inlet" valve—four parts (two valves and two guide plates) in addition to the piston, and only two moving parts, the ring valves. In the illustration herewith the ring valve may be compared, as to its simplicity, with the piston ring in the foreground—the latter a part of the compressor which almost never gives trouble.

The "Hurricane-Inlet" valve permits the most complete cylinder jacketing possible, this not only improving the compression efficiency, but causing better lubrication and sustained tightness of all joints. The construction admits the coolest possible gas to the cylinder; for the gas enters through the inlet tube which is cooled by constant contact with the head jacket. Moreover, the piston itself is cooled by the cylinder jacket. The gas enters in a solid column through the tube and in the form of a cylinder through the ports, everywhere encountering cool metal; so that it cannot be perceptibly raised in temperature in the fraction of a second required for a stroke at full speed.

The large and unobstructed inlet passages and ports, and the quick-acting, fully-opening valves, admit a full cylinder of gas at each stroke. Volumetric efficiencies of "Hurricane-Inlet" cylinders are extremely high. The perfect simplicity of the valve movement, the lightness of the valves, their slight lift, and the large intake areas



Ingersoll-Rand Class "C-4" Corliss Steam Driven Gas Compressor in the Ruffner Station of the T. W. Phillips Oil and Gas Co., Pa.

permit higher speeds without undue wear or loss of efficiency than is possible with any other construction; so that "Hurricane-Inlet" compressors have exceptionally large capacities per unit floor space.

Accessibility is another important advantage. By removing one or more discharge valves the ring valve can be turned by hand and inspected over its full circumference.

In fact, every important requirement of high-duty, economical gas compression is met in the fullest degree in the Ingersoll-Rand "Hurricane-Inlet" valve.

"Direct Lift" Inlet Valves

In certain sizes of Ingersoll-Rand Gas Compressors, "Direct Lift" inlet valves are used in place of the "Hurricane-Inlet" valve. In such cases the inlet and discharge valves are identical and interchangeable, making a small supply of duplicate valves ample for all ordinary emergencies. As the construction of the "Direct Lift" inlet valve is identical with that of the "Direct Lift" discharge valve, the description of the latter in the next section will suffice for both.

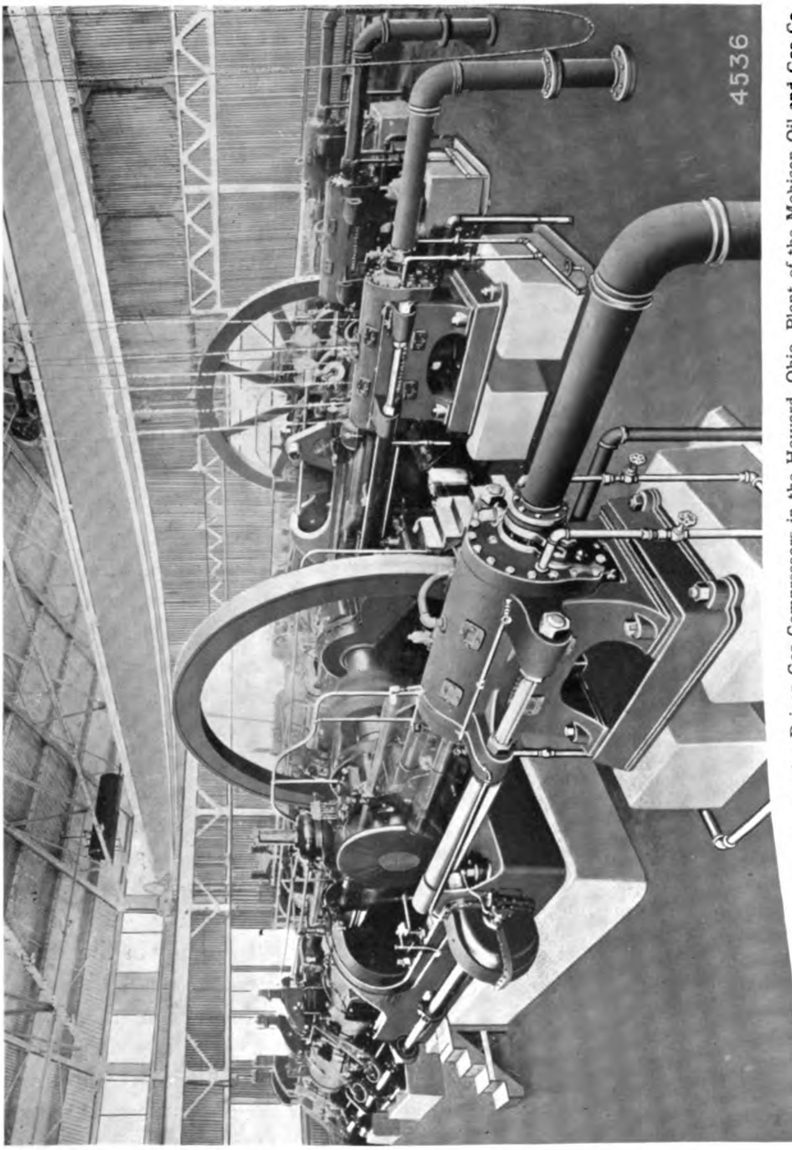
"Direct Lift" Discharge Valves

The "Cushioned Direct Lift" discharge valve is standard on all Ingersoll-Rand Gas Compressors. It is a positive, quick-acting type, affording the maximum discharge efficiency, and the maximum discharge area with a comparatively small lift.

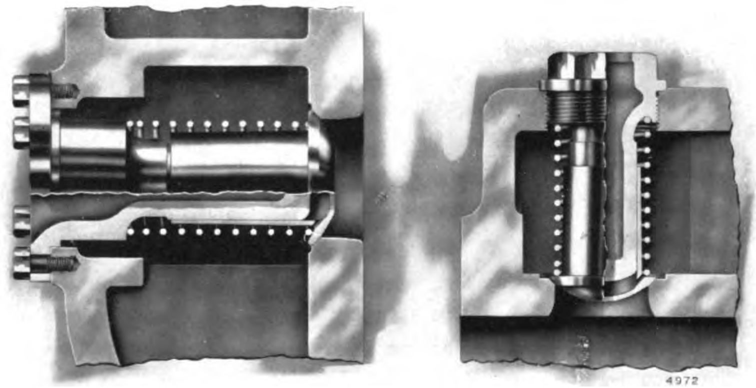
The valve proper is machined from a selected steel, oil-treated and annealed, and ground to an accurate seat. The cross-section is properly reinforced at points of maximum stress, and breakage is seldom encountered. The cap or valve guide is accurately ground to a wide guide surface, insuring the return of the valve to its seat with precision and tightness.

A small volume of air or gas is compressed between valve and guide at the end of the lift, affording a cushion which removes all shock at the end of the lift, but in no way interferes with the quick action of the valve.

In the smaller sizes this cap is screwed into the cylinder head, or barrel, as the case may be. In the larger sizes it is bolted in place. The large diameter of the valve, and its wide bearing on the guide surface of the cap, insure uniform wear on valve and seat, with no tendency to bind or destroy the proper shape of the seat. The valve is free to turn and is self-grinding. The spiral spring is of

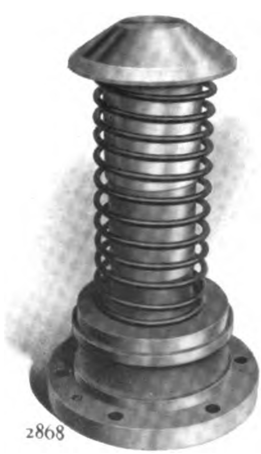


Two Ingersoll-Rand-Westinghouse Gas Engine Driven Gas Compressors in the Howard, Ohio, Plant of the Mohican Oil and Gas Co.



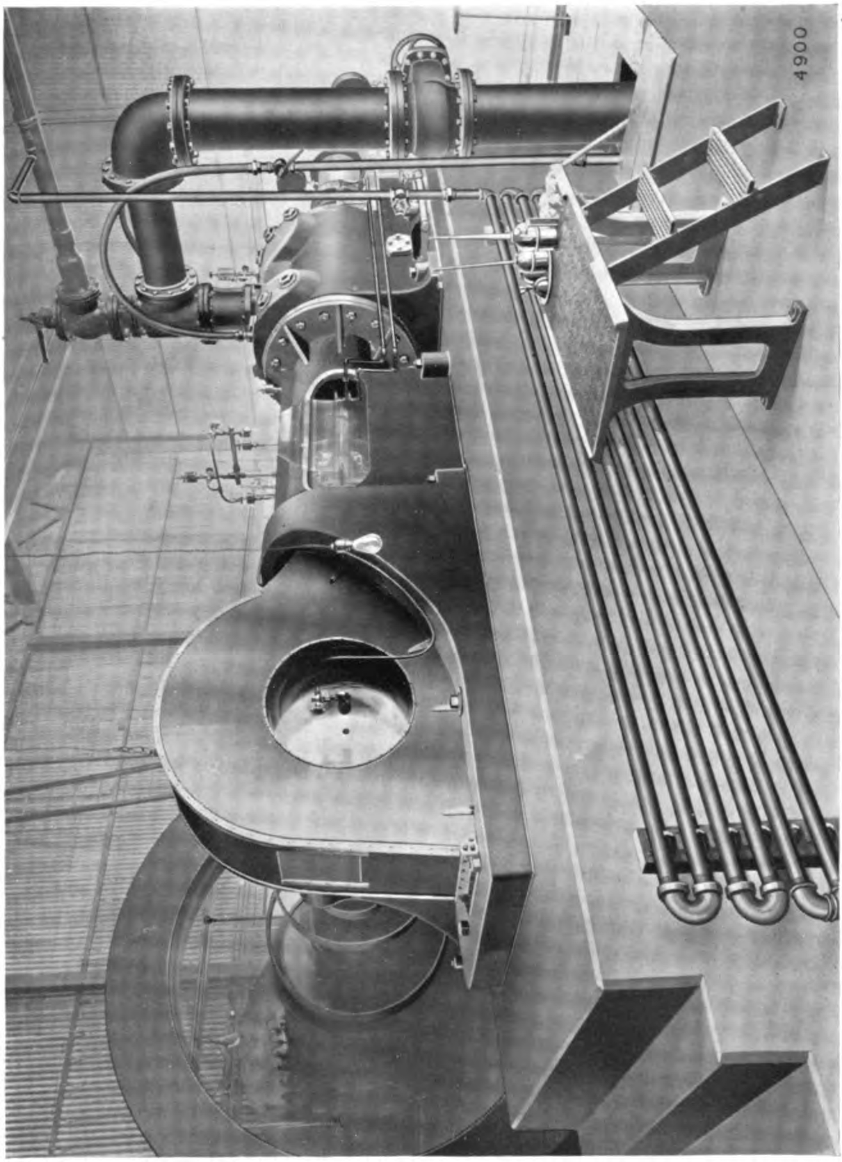
Sections of "Direct Lift" Discharge Valves, with Bolted and Screwed Plugs

the proper pitch and these valves are remarkably quiet in operation, even at the highest speeds. There are no webs, bridges or lips obstructing the port or passages, and the discharge area afforded by these valves is about 15 per cent of the cylinder area. These valves seat directly on the metal of cylinder head or barrel, as the construction renders unnecessary any removable or renewable valve seats. All types of the latter have been tried out at some time in the Company's experience and have been abandoned as entirely unnecessary with the present valve construction, and usually a source of trouble.



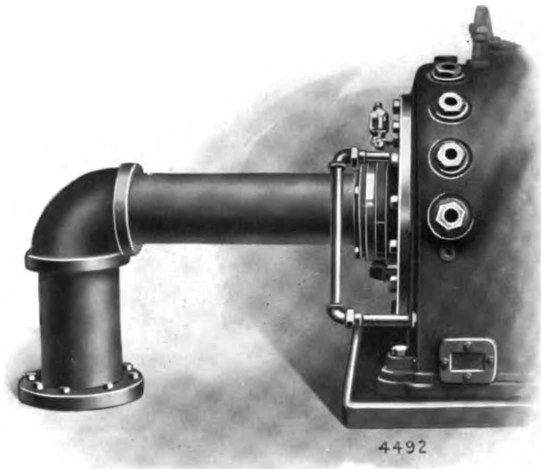
A Complete "Cushioned Direct Lift" Discharge Valve

In some types of Ingersoll-Rand Gas Compressors, the discharge valves are in the cylinder heads. In others they are arranged radially in the cylinder barrel. In all cases, discharge valve clearance has been made the smallest possible. The free exit of the gas compressed is facilitated by the very large discharge passages, the area of which in some cases amounts to more than half the cylinder area.



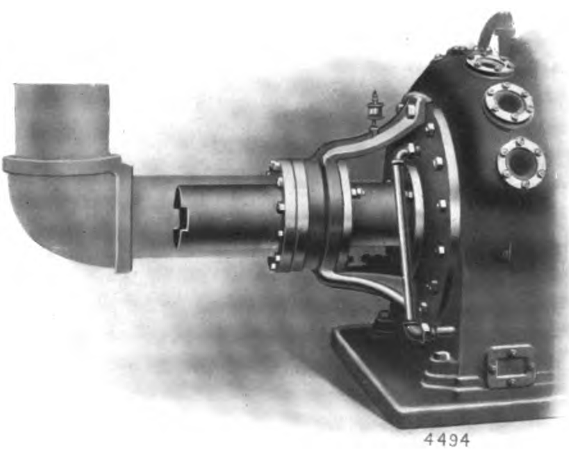
Ingersoll-Rand Class "D-1" Gas Compressor Direct Connected to Westinghouse Gas Engine in the Plant of the Union Utility Co., Morgantown, W.Va.

The Pressure or Gas Intake

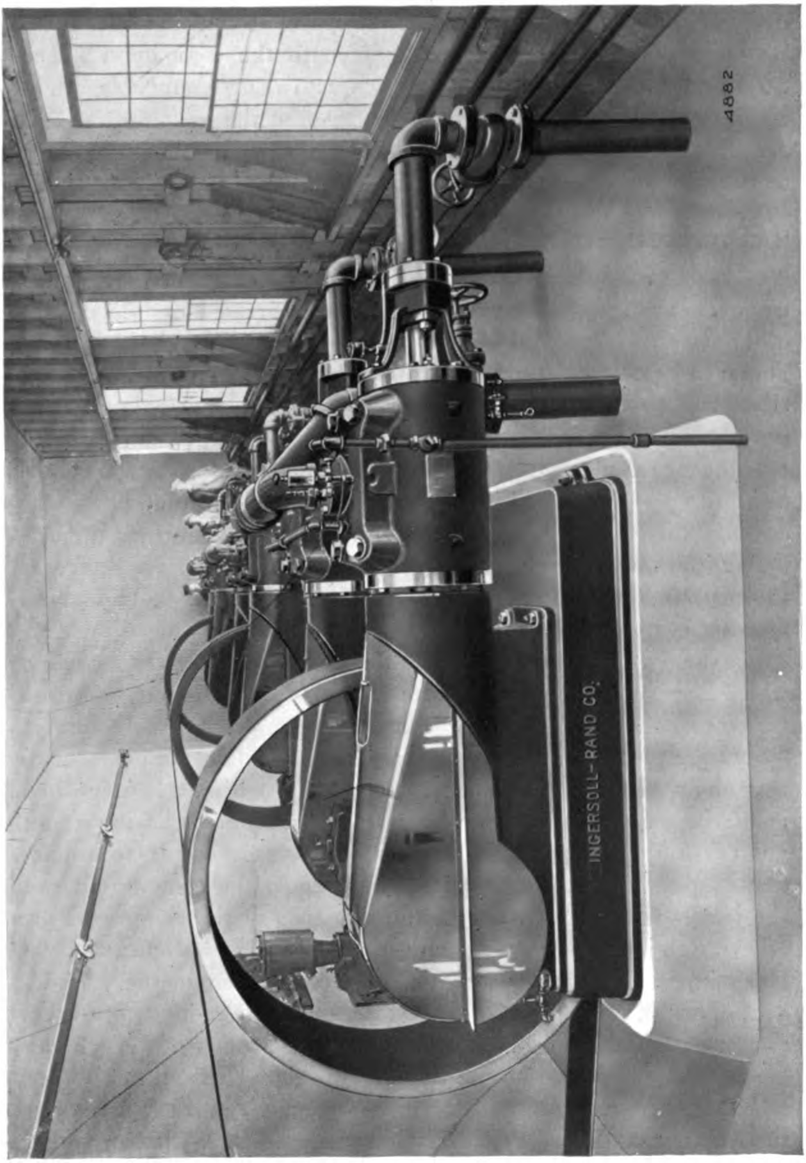


The Pressure or Gas Intake

The "Pressure or Gas Intake" is a perfectly tight intake connection designed for handling any inlet pressure or any vacuum, and developed especially for gas compression work. It consists of two lengths of pipe and an elbow. The horizontal member has a flange bolted directly over a gasket to the cylinder head and surrounding the inlet tube. The vertical member has a flange to which the pipe line is connected. If connections are properly made and all joints kept tight, there cannot possibly be any escape of gas with this arrangement. It is to be noted that this device requires no additional stuffing box, and perfect safety is assured. Pipe connections are made at the floor line.



The Extension Bracket



Three Ingersoll-Rand Class "J-1" Belt Driven Gas Compressors at Clymer, Pa., in the Plant of the T. W. Phillips Gas and Oil Co.

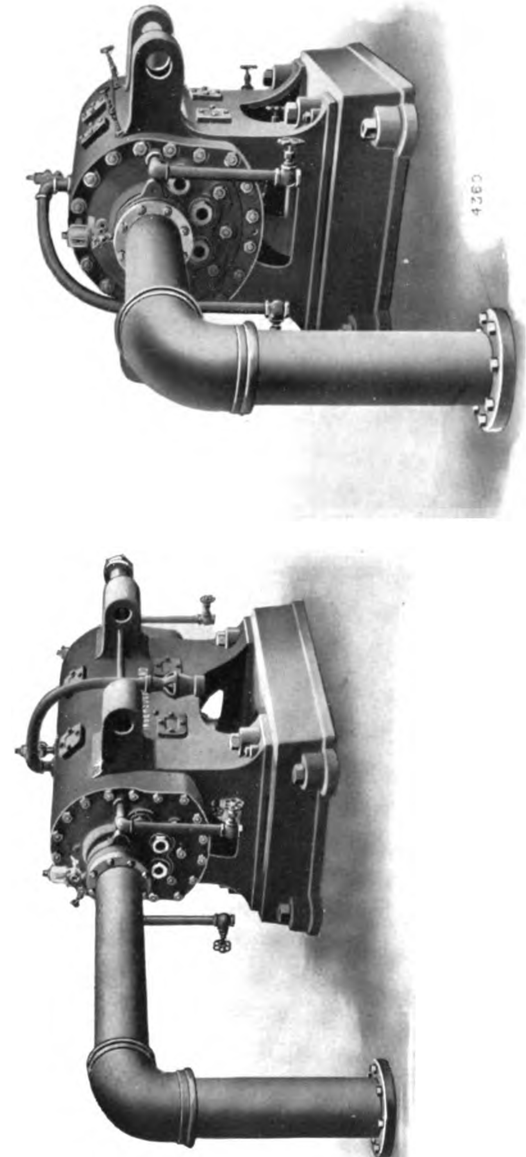
The Extension Bracket

The "Extension Bracket" is simply a casting bolted to the cylinder head, with an auxiliary stuffing box around the inlet tube. The customer connects his intake pipe to the companion flange furnished with this bracket, taking care to allow enough length in his horizontal member to permit the travel of the inlet tube. This arrangement is adapted only to intake pressures up to fifty pounds or to vacuums not exceeding four or five inches.

"Hurricane-Inlet" Gas Cylinders

"Hurricane-Inlet" gas cylinders in the larger sizes are made up of a shell with a removable bushing pressed in place. In other sizes the shell and bore are cast solid. The bore has an ample margin of safety to permit re-boring. If desirable, in larger sizes, the bushing can later be easily removed and replaced by a bushing of the same diameter; or, within reasonable limitations, a bushing of smaller diameter may be substituted to meet conditions of pressure which may have developed in that particular case. Cylinder heads are of the same quality of iron as the cylinder, thoroughly webbed or ribbed, and of proper thickness to withstand maximum pressures without springing. The heads are cast in one piece.

Particular attention is called to the unusually complete jacketing which is permitted by the construction of these cylinders. On the exterior of the cylinder shell a number of hand-holes with suitable covers are placed at proper intervals, thus enabling the operator to thoroughly clean out all mud or sediment which may be deposited in the jacket space by the circulating water. This is an important point which should be carefully looked after, as if this accumulation is allowed to form, it materially reduces the cooling effect of the jacket and seriously affects the efficiency of the compressor by allowing the gas to heat to a higher degree than is proper. It will be noted that particular attention has been given to the cylinder head jackets, which are a most essential feature in compression economy, as the gas is longer in contact with the face of the cylinder heads than with any other part of the cylinder. It is an established fact that the temperature of the discharge gas is much lower where the "Hurricane-Inlet" type of cylinder is used than with any other type of cylinder under like inlet and discharge conditions. When "Hurricane-Inlet" cylinders are directly connected by means of



A Pair of Standard Ingersoll-Rand Gas Compressor Cylinders with "Hurricane-Inlet" and "Cushioned Direct Lift" Discharge Valves

tie rods to either gas or steam engines, in the larger sizes and for the higher pressures, each cylinder is fitted with four cored lugs, two on each side, cast immediately back of each head. By using two lugs in place of one, as is the general custom, the strains are distributed throughout the entire length of the cylinder.

All "Hurricane-Inlet" gas cylinders are equipped with indicator openings, jacket drains, hand-holes and intake connections. Three-way mechanical lubricators, and metallic packing on piston rods and inlet tubes, are furnished on larger sizes. But on smaller cylinders and for lower pressures, the last two accessories are supplied only at extra cost.

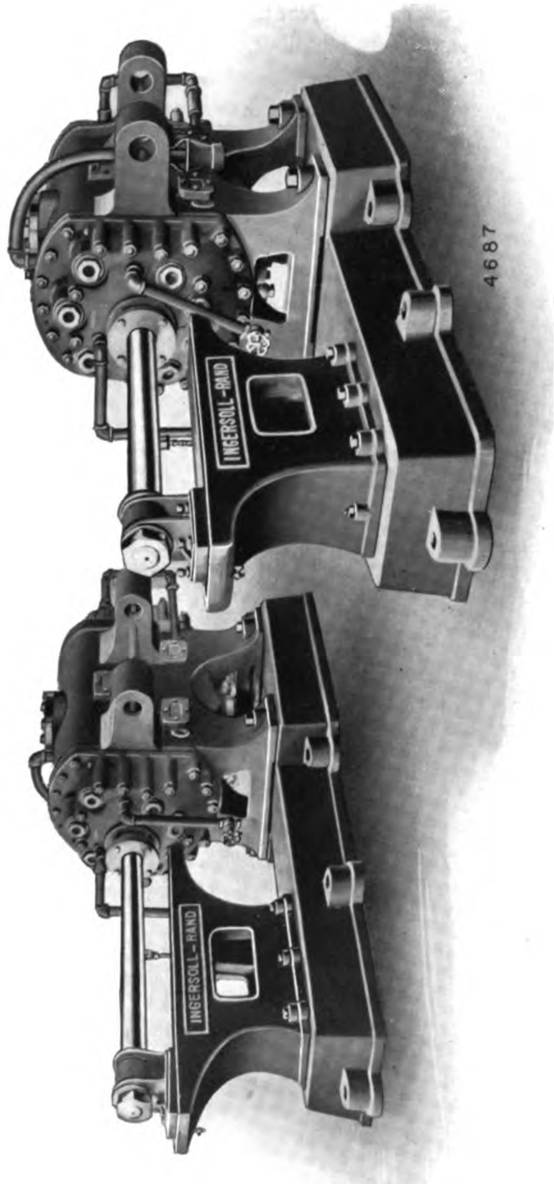
As a result of the splendid valve movements and the other economical details of "Hurricane-Inlet" gas cylinders, these machines give a higher volumetric efficiency, a greater quantity of gas actually delivered at lower temperatures, with less repairs and fewer costly shutdowns, than any other type of gas compressor.

"Direct Lift" Inlet Gas Cylinders

Under certain conditions, which are best determined by the Company's gas engineers, Ingersoll-Rand gas cylinders are furnished with "Direct Lift" inlet and "Cushioned Direct Lift" discharge valves, of the type already described. The mechanical construction of these cylinders, aside from the details involving the valve movements, is the same as that of "Hurricane-Inlet" cylinders. "Direct Lift" valve cylinders are made with either flat or conical heads and with either flat or conical pistons. Tail rods and sole plates may be furnished on order.

A very important feature to be noted in connection with this type of cylinder is the fact that the inlet and discharge valves are identical in construction, and, therefore, interchangeable. Both valves are immediately accessible and afford maximum areas. The same general equipment is included with "Direct Lift" valve cylinders as has just been described for cylinders of the other type.

On page 21 is an illustration of a pair of 48-inch stroke "Direct Lift" inlet valve gas cylinders with sole plates and tail rods. These cylinders were designed for a discharge pressure of 350 pounds per square inch.



A Pair of Standard Ingersoll-Rand Gas Compressor Cylinders with "Direct Lift" Inlet and Discharge Valves

In Conclusion

Summarizing the exclusive advantages in the design, construction and performance of Ingersoll-Rand Gas Compressors, the following features are to be especially borne in mind:

The maximum areas of inlet and discharge ports and passages secured by the valve designs assure the highest compression efficiency and the lowest power charge for compression.

The greatest possible amount of cylinder surface, both on barrel and heads, is water jacketed, resulting in the minimum heating of the gas and in ample cylinder lubrication, meaning absence of wear.

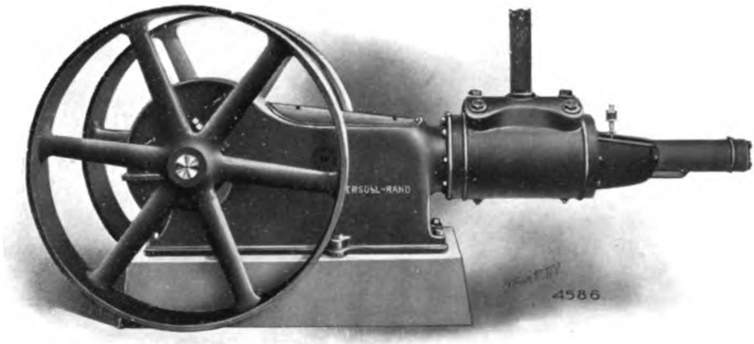
Experience and test have justified the claim, on the part of the Company, that Ingersoll-Rand Gas Cylinders will show, under proper care, a higher economy of performance than those of any other builder.

Guarantees

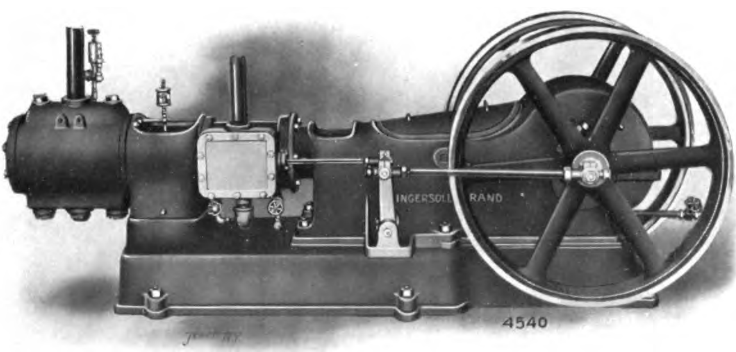
The standing guarantee of the Ingersoll-Rand Company is to make good at its works, by repair or replacement, any defect in the workmanship or material of its compressors which may develop within one year from date of shipment.

The Ingersoll-Rand Company furthermore furnishes its compressors under a standing guarantee of interchangeability of wearing parts.

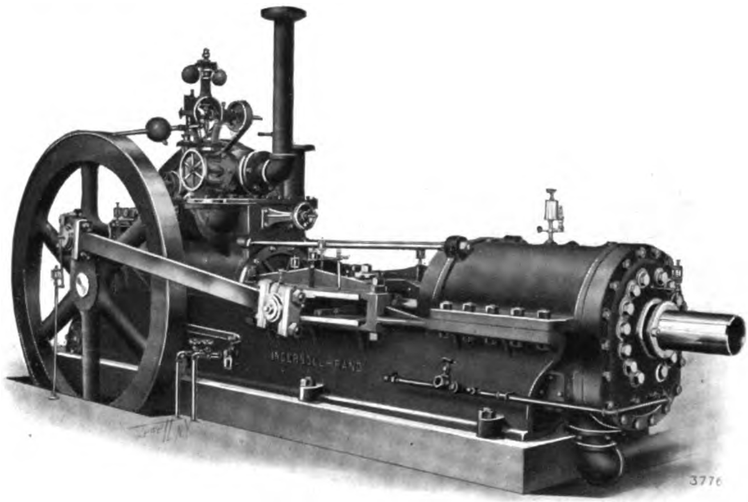
The Ingersoll-Rand Company further guarantees that such is the care exercised in the selection of materials, in the workmanship applied, and in the methods of production, that its compressors, under fair treatment and reasonable freedom from abuse, will give better results with the minimum of delay and expense for repairs, for a longer period than those of any other builder.



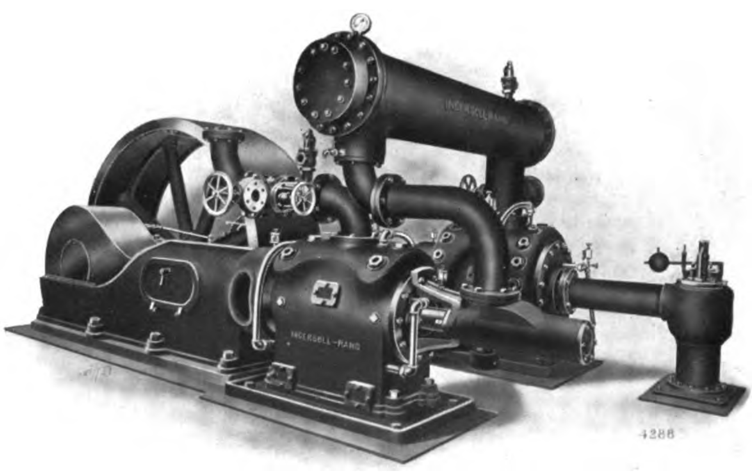
Standard Class "NE-1" Compressor with "Hurricane-Inlet" and "Direct Lift" Discharge Valves. Construction on the Six Larger Sizes: Smaller Sizes have "Direct Lift" Inlet Valves



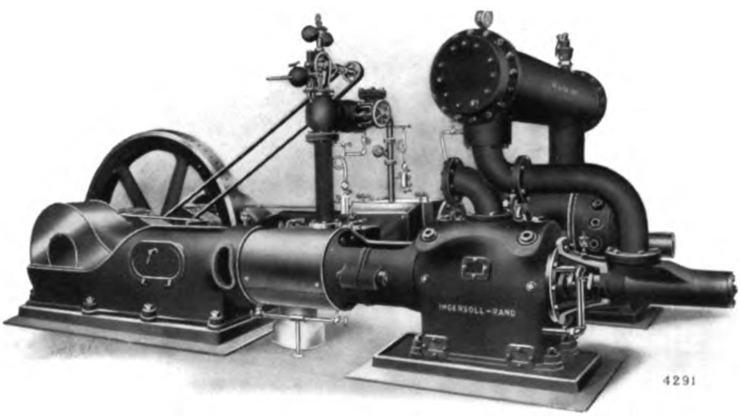
Class "NF-1" Compressor with "Direct Lift" Inlet and Discharge Valves. Standard Construction on Sizes up to and including 10 and 12 x 10 inches: Larger Sizes have "Hurricane-Inlet" Valves



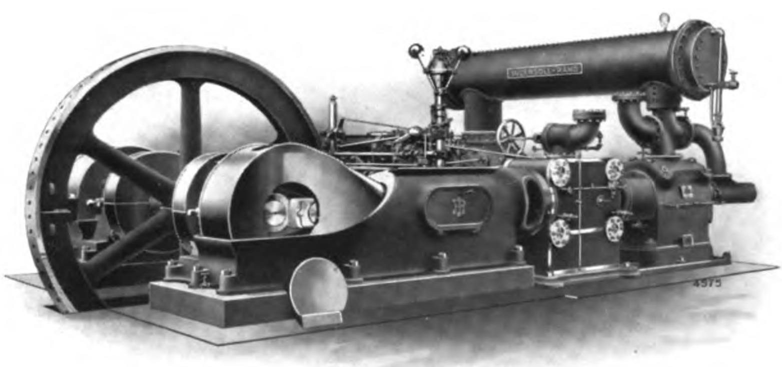
Standard Class "A-1" Air or Gas Compressor



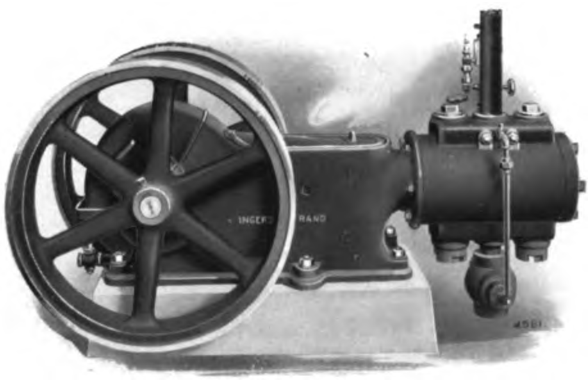
Standard Class "PB-2" Power Driven Air or Gas Compressor; Also Furnished with Simple Duplex Cylinders



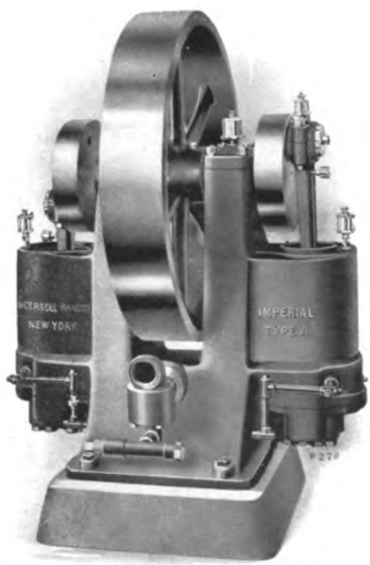
Standard Class "O-3" Air or Gas Compressor: Furnished also with Simple Duplex Steam and Gas Cylinders



Standard Class "OC-3" Corliss Steam Driven Air or Gas Compressor: Furnished also with Simple Duplex Steam or Gas Cylinders

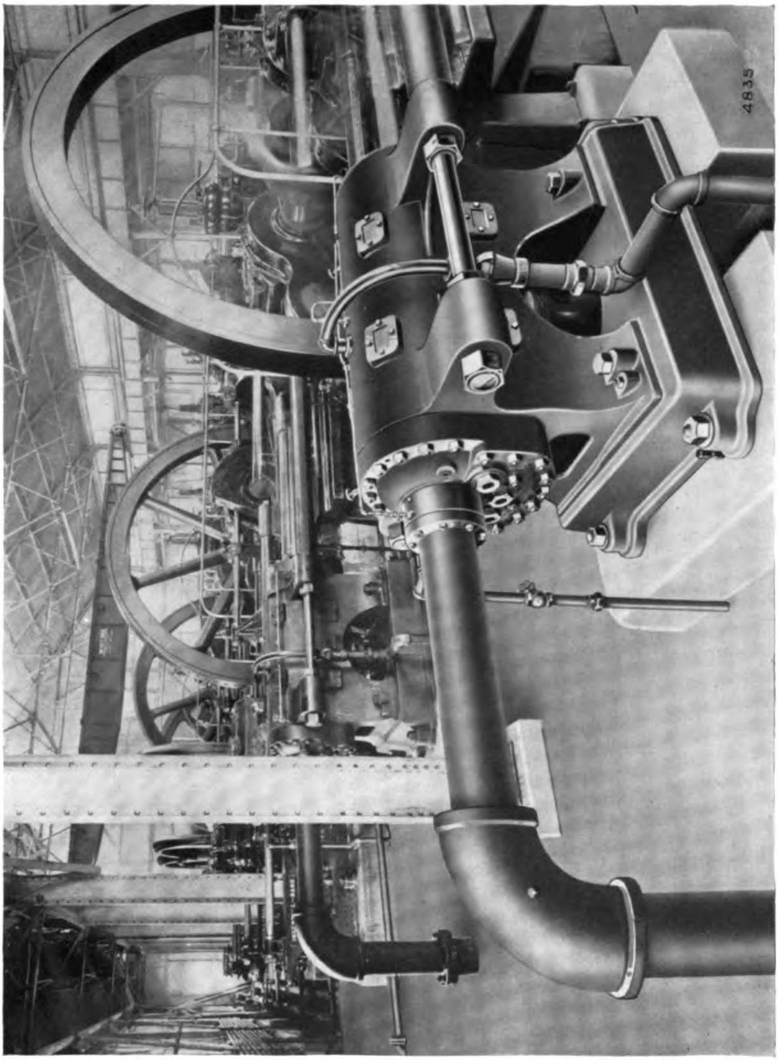


Standard Class "NE-1" Compressor with "Direct Lift" Inlet and Discharge Valves

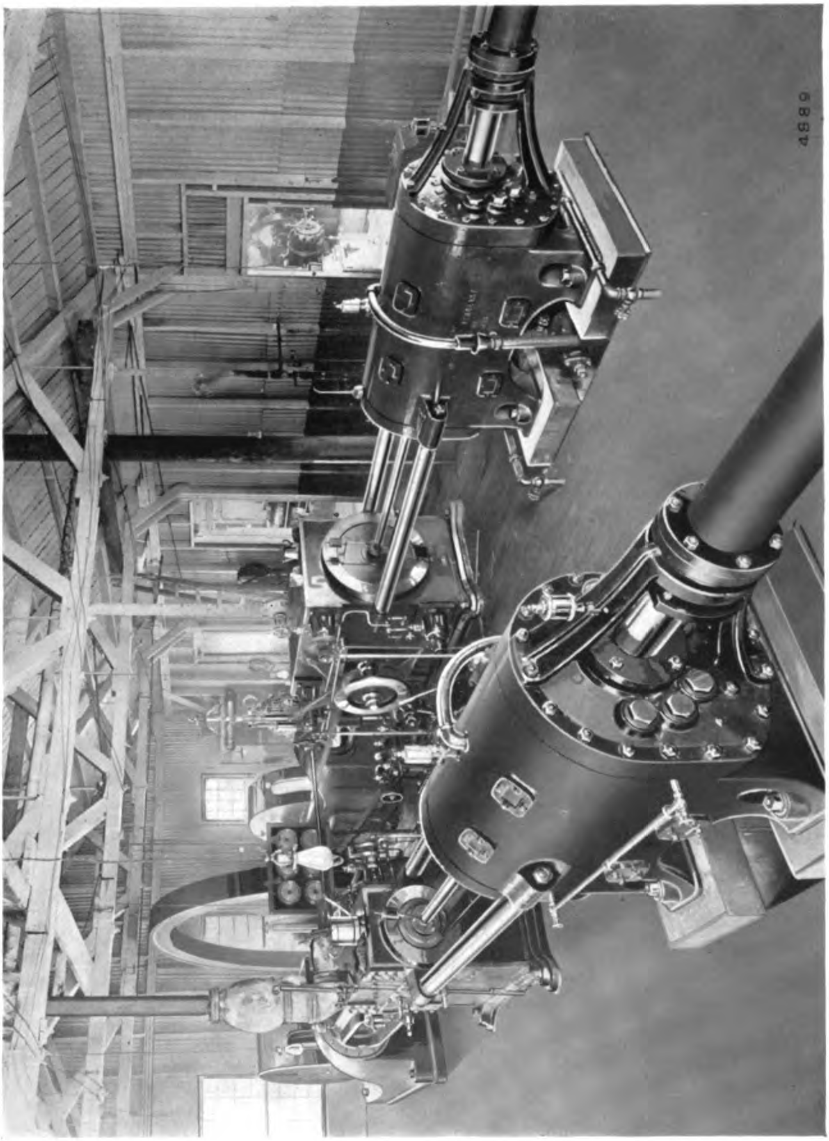


Standard "Imperial XI" Duplex Power Driven Compressor

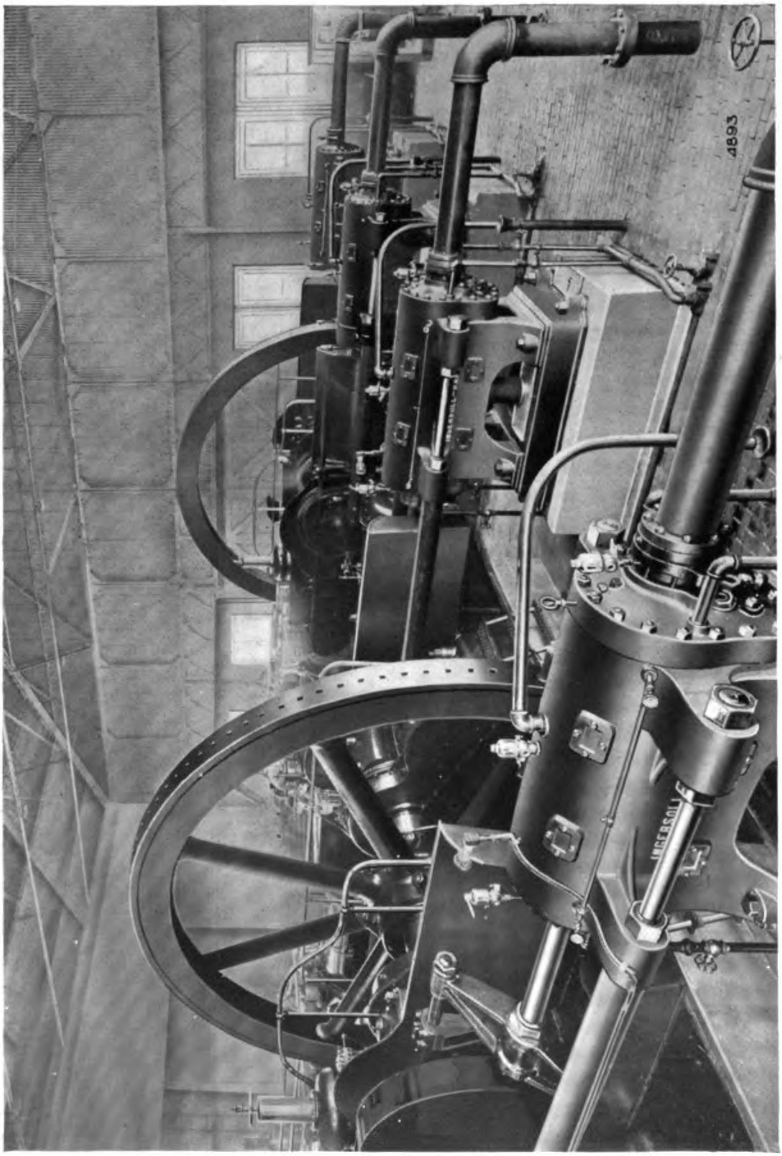
The two compressors here illustrated are especially adapted for starting gas engines where a high pressure is wanted, but only for short periods.



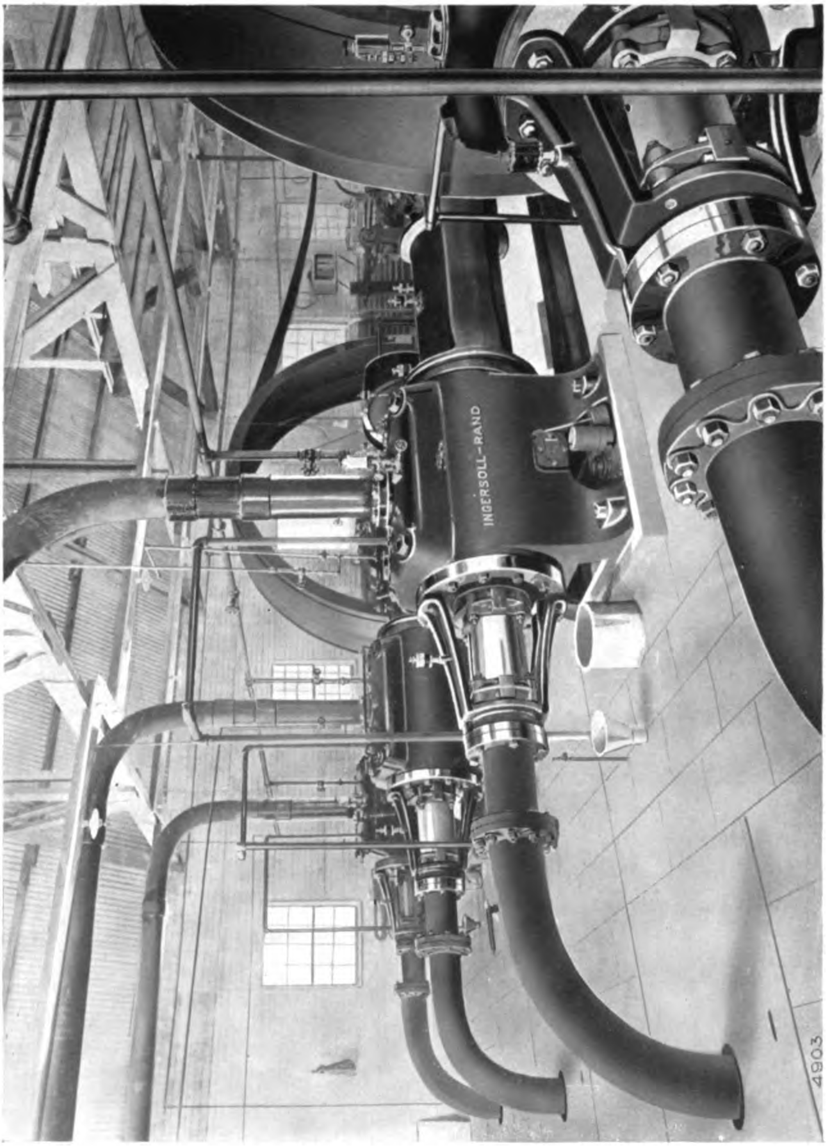
Three Ingersoll-Rand-Westinghouse Gas Engine Driven Gas Compressors in the Plant of the Columbia Gas and Electric Co., Kenova, W. Va.



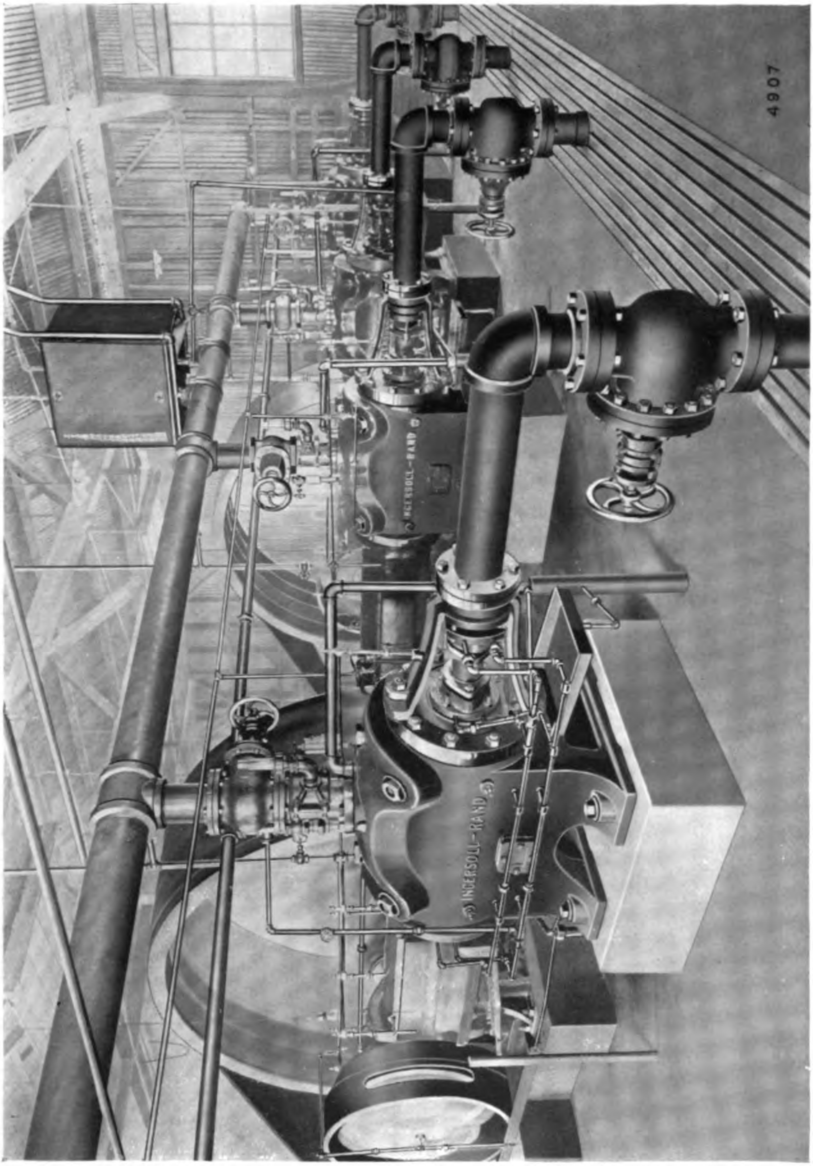
Ingersoll-Rand Class "C-4" Corliss Steam Driven Gas Compressor at Stone House, Pa., in the Plant of the American Natural Gas Company



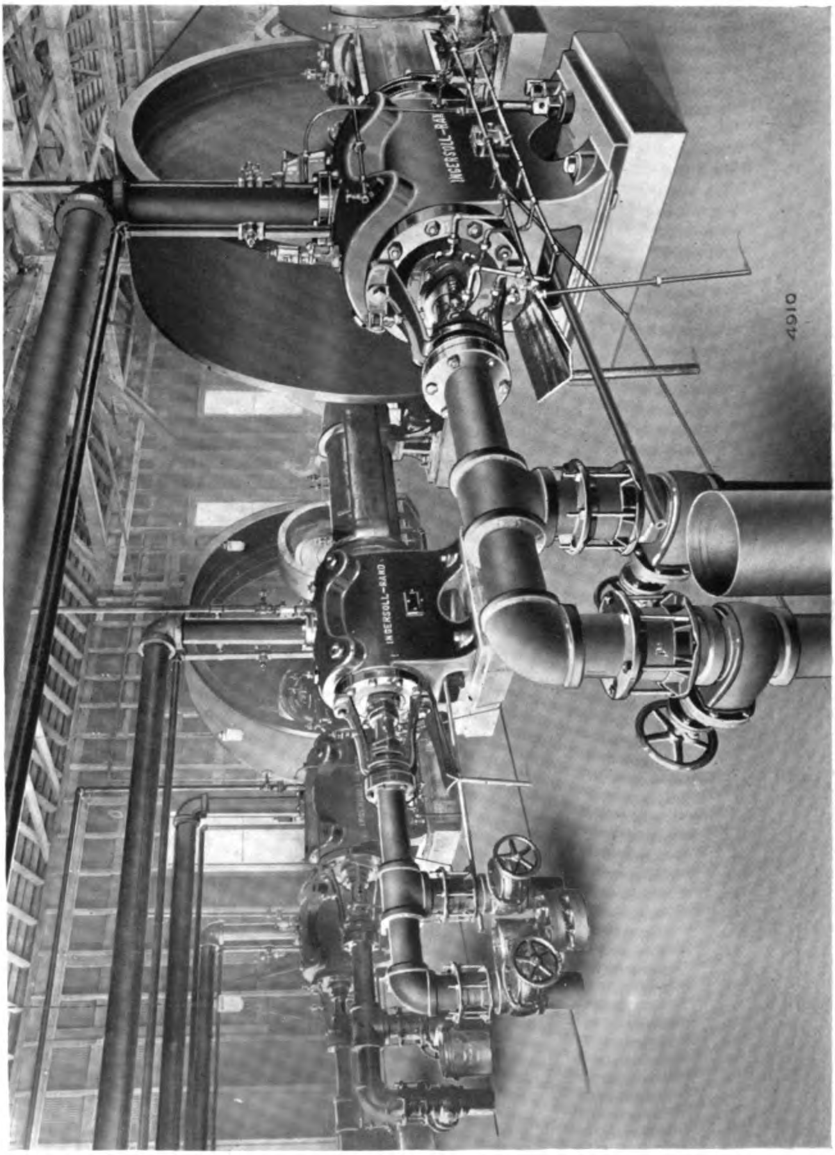
Two Ingersoll-Rand-Westinghouse Gas Engine Driven Gas Compressors in the Plant of the Mohican Oil and Gas Co., Ohio



Two Ingersoll-Rand Class "D-1" Belt Driven Gas Compressors in the Plant of the Greensboro Natural Gas Co., Bentleyville, Pa.



Two Ingersoll-Rand Class "D-1" Gas Compressors in the McKinley, Pa., Plant of the Manufacturers Gas Co.



Two Ingersoll-Rand Class "D-1" Belt Driven Gas Compressors at Roulette, Pa., in the Plant of the Potter Gas Co.

GRIFFITH - STILLINGS PRESS
368 CONGRESS ST., BOSTON

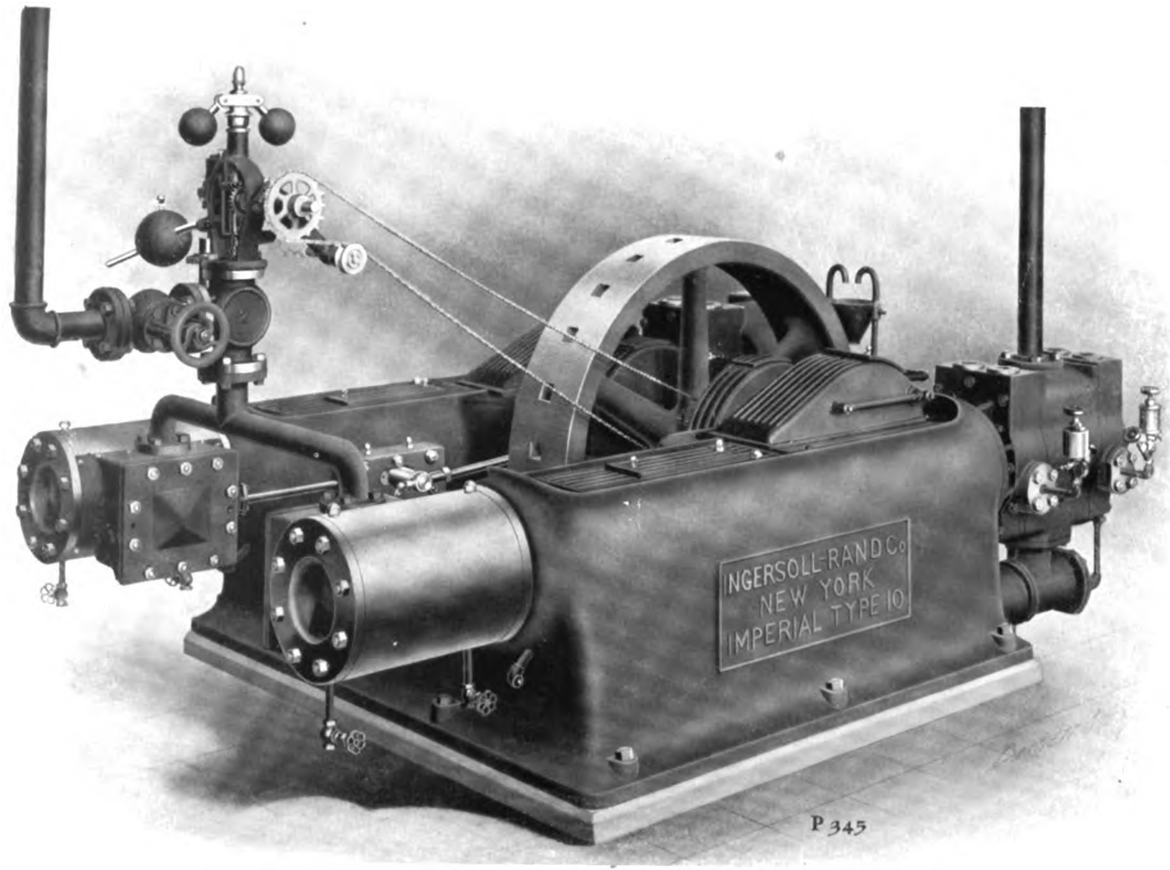
Form 534

"IMPERIAL" TYPE TEN DUPLEX STEAM-DRIVEN AIR-COMPRESSORS

Instructions for Installing and Operating

INGERSOLL-RAND
COMPANY
11 Broadway
New York

February, 1911



"Imperial" Type X-2 Compressor with Intercooler in Main Frame Standard Construction, on 10" 12", 14" and Light 16" Stroke Machines

General Instructions Covering the Installation and Operation of Ingersoll-Rand "Imperial" Type Ten Air-Compressors

These instructions are given for the purpose of assisting in the proper installation of the compressor and to give the operator a clear understanding of the manner in which the several parts perform their duties. For this reason these pages should be read carefully before doing any work on the compressor outfit.

FOUNDATION

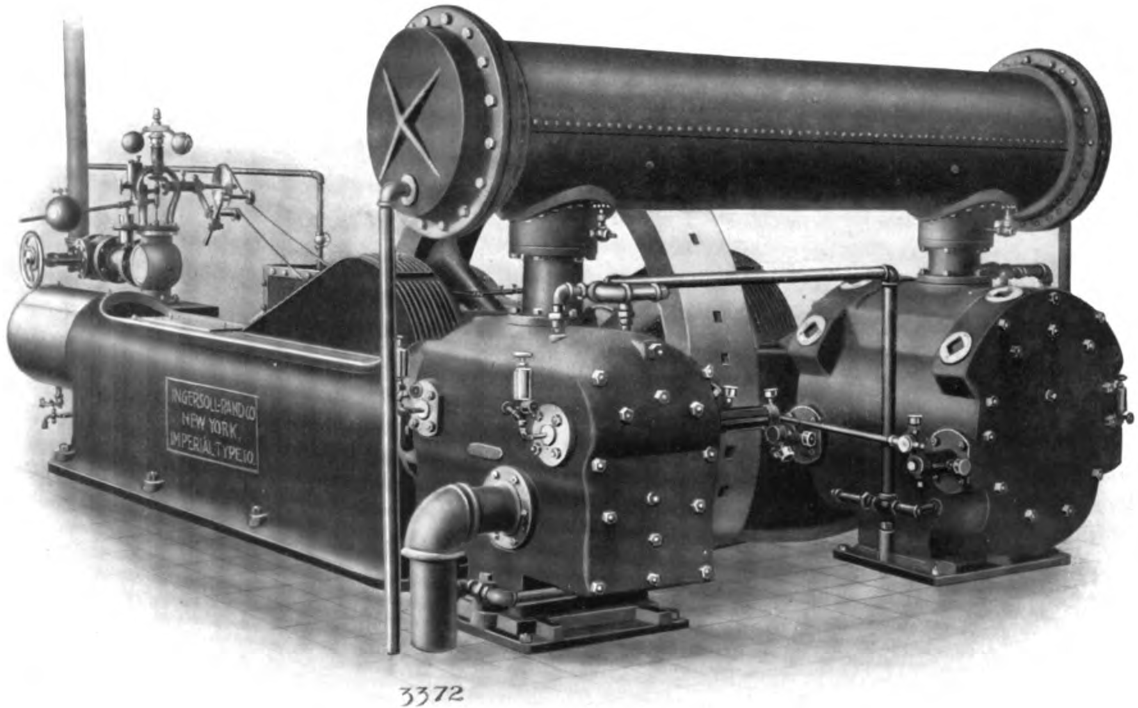
Plans are furnished with each compressor, which give dimensions for a suitable foundation. Such plans are made with the assumption that the foundation is to rest on firm and solid ground; if this is not the case, it should be larger than shown on the drawing, and a bed of concrete made to carry it. This bed should be at least one foot thick, and should extend considerably beyond the outside edges of the compressor foundation.

The foundation may be built of hard burned bricks laid in cement mortar, with thin and well grouted joints. Satisfactory foundations may also be constructed of concrete. When concrete is used, we recommend that it be reinforced by a number of iron rods about one-half inch in diameter imbedded in it near both top and bottom. Some of these rods should be placed lengthwise and others crosswise of the foundation.

A template should be made of wood to correspond exactly to the foundation plan furnished. After putting the template together, however, it should be gone over carefully to see that its dimensions check with those given on the foundation plan. Lines should be marked on the template showing the centers of the cylinders and shaft. It should be placed in the exact position in which it is desired the compressor shall set, and at such height as to bring the upper ends of the anchor-bolts, which are suspended from it, at the proper distance above the floor line, as shown on the foundation plan.

As the template may receive rough usage during the construction of the foundation, it should be firmly secured in place to eliminate danger from being shifted from position.

The workmen should be cautioned to exercise proper care, but at the same time it is indispensable to have the template well secured.



"Imperial" Type X-3 Compressor with Overhead Intercooler, Standard Construction, on Heavy 16" Stroke Machines and Larger

To allow for variations in castings, sufficient space should be left around each anchor-bolt to permit a movement of about one inch in every direction. The most satisfactory way of accomplishing this is to use a piece of pipe of suitable size, slipped over the bolts, and the bolts secured centrally in them. These pieces should be of such length as to bring their upper ends just below the surface of the foundation, and may be left in after the foundation is completed. Pieces cut from old boiler flues are satisfactory, and are usually readily obtained. Light wooden boxes may be used, but pipe is better.

About three-quarters of an inch should be left between the top of the foundation and the level at which the bottom of the base of the compressor is set. This space is to be filled with cement after the compressor is properly leveled on wedges, as described below.

SETTING

When the foundation is completed and thoroughly "set" the compressor may be lowered upon it, at the same time guiding each anchor-bolt into its proper hole in the frame. Iron wedges are to be provided for leveling, and one inserted near each anchor-bolt, between the foundation and the base of the compressor. These are to be driven in so as to bring the machine perfectly level without strain.

Every precaution should be taken to have the compressor set level, as this assures correct adjustment and alignment throughout.

The Main-Bearings should set level and be level with each other. To assist in accomplishing this end, spots are planed on the frame near each bearing for supporting a straight-edge. Care should be exercised to secure an accurate straight-edge, and, in all cases, it should be reversed and again tried with a level, in each position in which it is used, so as to check any possible error. If it is necessary to block up for the straight-edge, be sure that the blocks used at each end are of exactly the same height.

The steam cylinders should be made level with each other; and the cross-head guides, on each side of the compressor, should be level both lengthwise and crosswise.

The wedges that support the compressor at various points are to be driven so as to bring the machine to its proper height. The compressor should bear about equally on all the wedges after the leveling is completed, but even if this is not the case, it is of minor importance compared with having all the principal parts of the compressor level.

After leveling is completed, the nuts on the anchor-bolts should be tightened up just enough to make the machine set firmly on the wedges. After tightening the nuts, it is better to go over all the machine again with a level before pouring the grout.

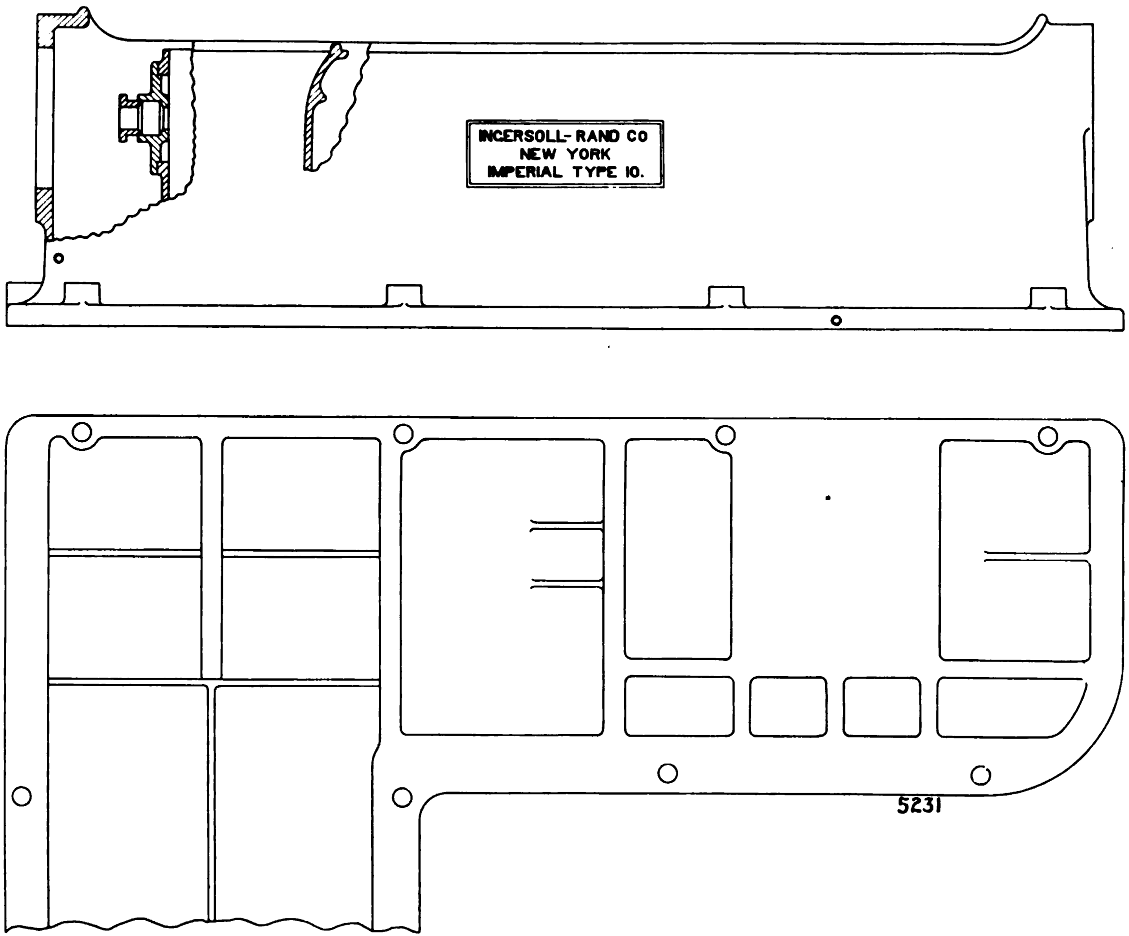


Figure 1—Main Frame for "Imperial" Type X Air Compressor

A dam should then be formed around the edge of the base, about two or three inches higher than the bottom of the compressor. This may be readily made of damp clay; of a tier of brick with joints stopped with mud; or of strips of board nailed together with the joints made tight with any available material. A sufficient quantity of grout should then be prepared. This may be made of Portland cement, or of a mixture of one part of clean sharp sand to two parts of Portland cement, with just enough water added to make it flow freely. Pour the grout into the enclosure built about the base of the compressor, and it will flow under it, filling the holes left around the anchor-bolts, and the space between the base of the machine and the surface of the foundation, so that when the cement sets the frame will have an equal bearing at all points. To be sure that no pockets or air spaces form underneath the base of the frame, which would prevent the grout from filling in solidly, it is well to puddle it under the edges of the frame with a trowel, or a piece of hoop iron bent to convenient shape. When the grout is nearly set, the dam may be removed, and the grout that projects beyond the base trimmed off. When it is thoroughly set, the nuts on the anchor-bolts are to be screwed down tight, and the setting of the machine is completed.

MAIN FRAME

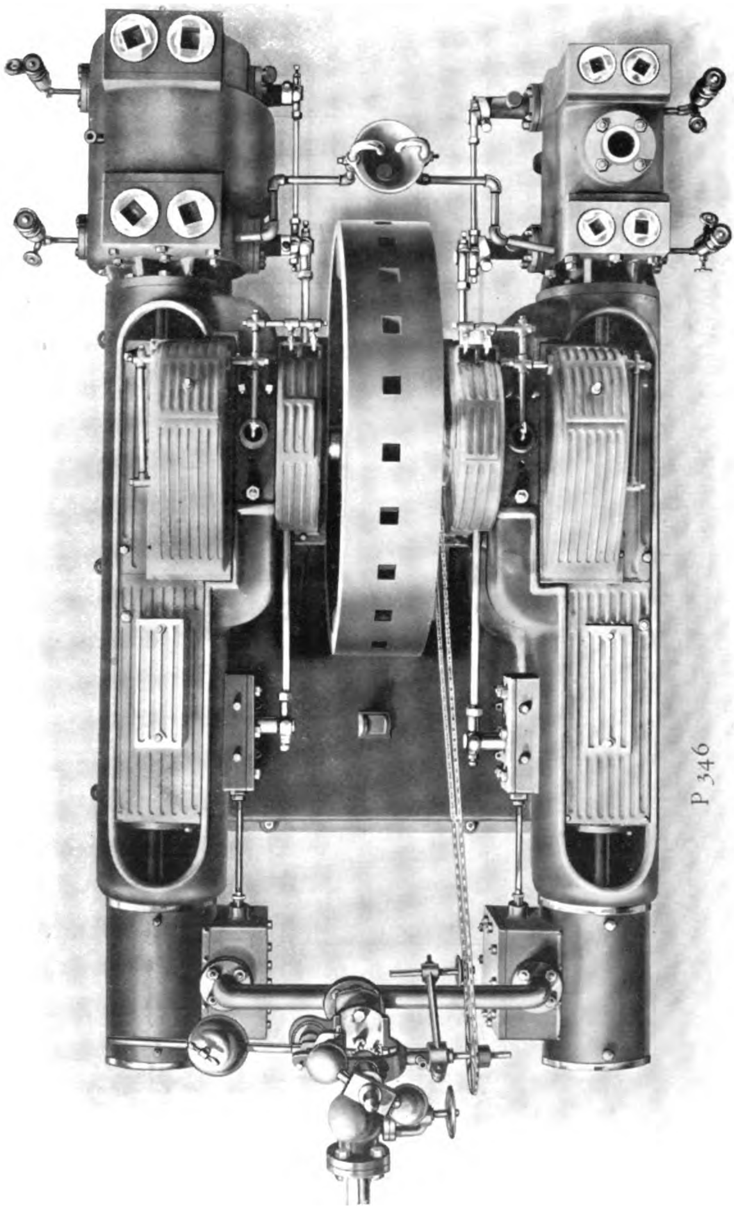
On compressors up to and including the heavy 16″ stroke the main frame is cast in one piece, but is sometimes made in halves if so ordered. On compressors larger than the heavy 16″ stroke the main frame is cast in halves to facilitate transportation.

The seat for the main bearing is cast in the frame, which is designed to be self-contained and to resist the strains of operation. The upper part is of a barrel shape and is reinforced by ribs. The lower part is practically of straight line construction, strongly cross-ribbed to insure rigidity.

The base is provided with very generous bearing surface where it rests on the foundation, especially under the main bearing.

On the ends to which the steam cylinders are connected, a partition plate with a stuffing box and gland is provided, the object of which is to prevent any condensation, which may escape through the steam cylinder stuffing box from being carried over into the frame, mixing with the oil in the crank basin which is used as a reservoir for oil to supply the lubricating system. The condensation falls into the chamber between partition plate and frame end, and may be drained off at will through a bib-cock, which is screwed into a tapped hole.

A bib-cock screwed into a hole, which is drilled on a level with bottom of crank basin, serves for removing the lubricating oil when necessary.



Looking Down on an "Imperial" Type X-2 Air Compressor

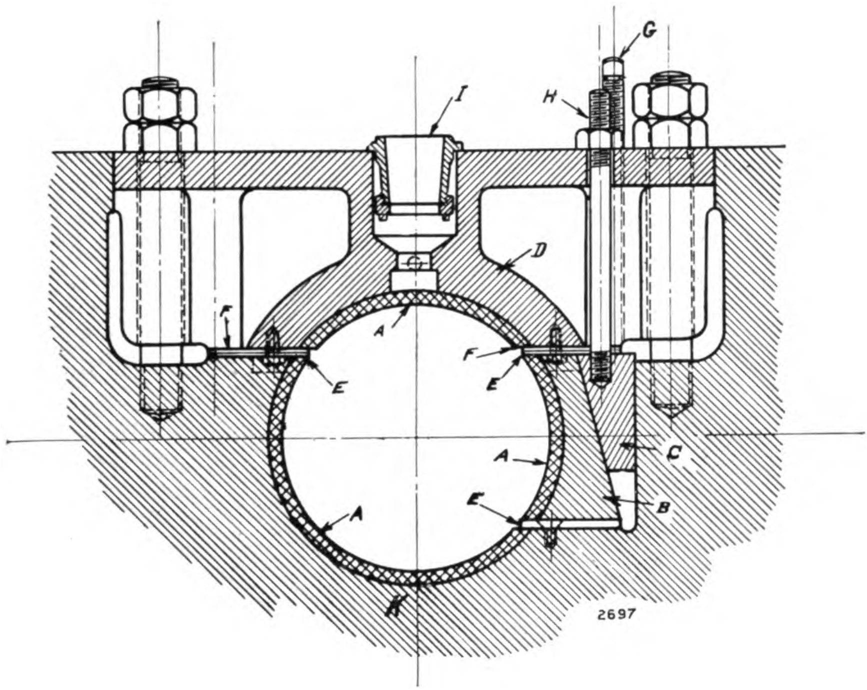


Figure 2—Main Bearing

MAIN BEARING

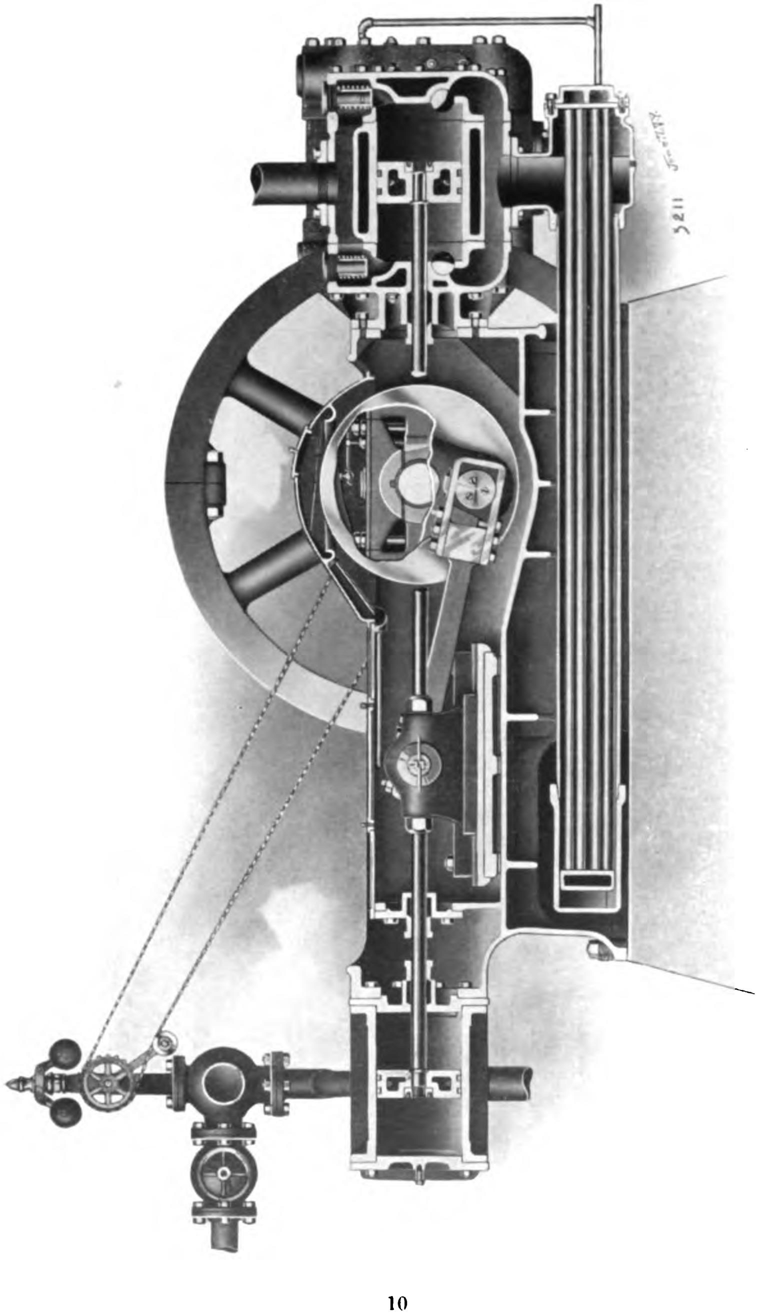
The main bearing is made in three parts and is provided with vertical and horizontal adjustments.

The seat "K", Figure 2, is cast in the frame; it is assembled with the side bearing block "B", wedge block "C", and cap "D", and then bored in true alignment with a center line lengthwise through frame.

The bearing proper is a cylindrical shell "A" of anti-friction metal, turned to fit the seat "K" and bored to suit the shaft. It is cut into three parts as shown on the illustration, and is kept from turning by steel plates "E", which are secured by screws to cap "D", and seat "K", respectively.

Liners are provided at "F" for vertical adjustment, while adjustment in a horizontal direction is secured by means of a wedge block "C". To make adjustment for loose bearing, loosen nut on stud "H" and force down the wedge block "C" by turning adjusting screws "G" clockwise the necessary amount, then tighten nut on stud "H". For tight bearings, slack up on screw "G" and set up nut on stud "H".

An oil box "I", having a strainer, is provided to receive oil from the lubricating system.



Section Through High-pressure Side of "Imperial" Type X Compressor. Standard Construction on Light 16" Stroke and Smaller

This type of bearing provides for easy renewal when necessary, for by raising the shaft a small amount the worn bearing may be rolled out and a new one substituted. By putting new bearings in both sides the machine is restored to its original alignment. Oil is supplied at all times sufficient to flood the bearing.

CROSSHEADS

The crosshead is of the slipper type, designed so that the shoe has a very generous bearing surface. The lower face of the shoe is made up of a series of tongues and grooves, which are machined tapering on the sides to match with the intermediate guide plate "B", Figure 3.

In assembling top guides they are provided with several liners of varying thicknesses at "G", so that in case of correction for wear being needed a liner may be removed or replaced by one having the necessary thickness to give correct adjustment. Should it be necessary to raise guide plate "B" liners may be put in at "H".

Top guide plates "F" should be kept in such adjustment that there is just a good working fit for the crosshead.

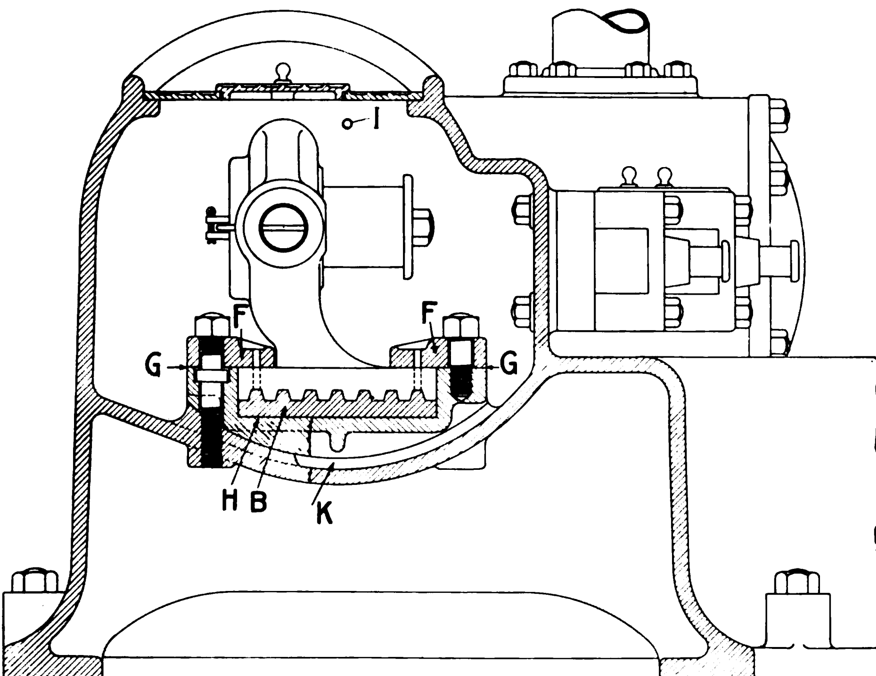
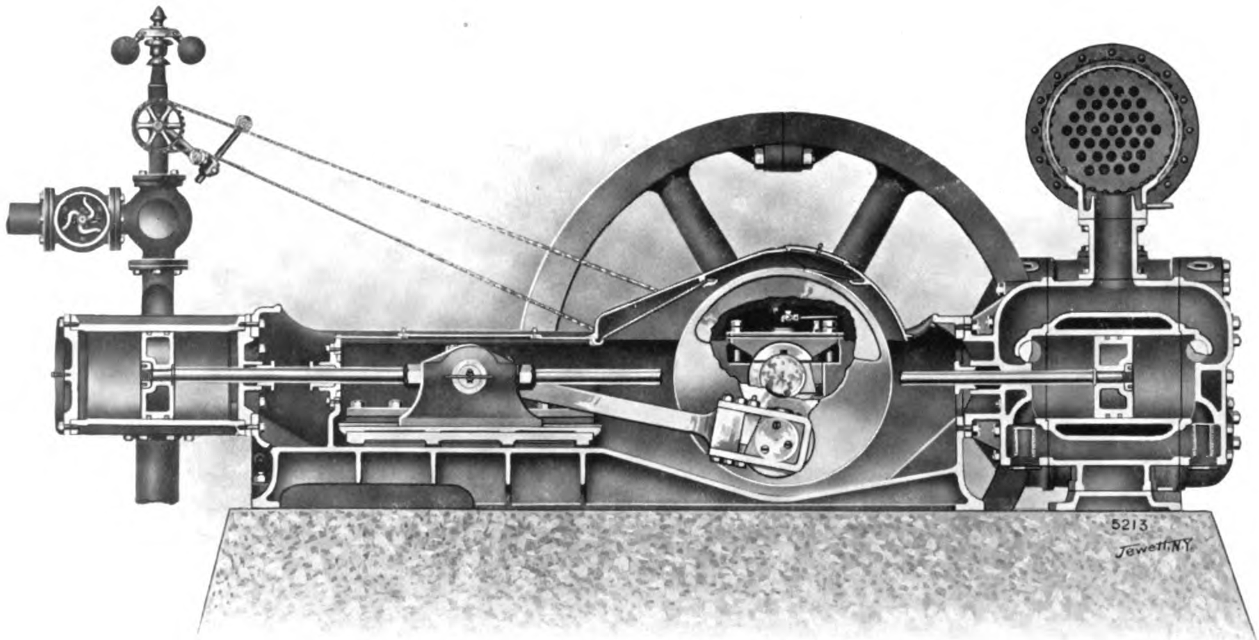


Figure 3—Section of Crosshead on "Imperial" Type Ten Compressor



Section Through High-pressure Side of "Imperial" Type X Compressor. Standard Construction on Heavy 16" Stroke and Larger

Crosshead pins are pressed into crosshead eye, and are of liberal proportions; and the bearing is hardened and ground.

Pin bearing and guides are kept constantly flooded with oil from the lubricating system through pipes "I", excess oil is returned through channel "K" to crank basin for redistribution.

The foregoing arrangement is used on light 20″ stroke, 1312 cu. ft. capacity machines and smaller. The arrangement used on "heavy" 20″ stroke, 1692 cu. ft. capacity and larger is somewhat different, in that the seat in the frame is planed to receive the intermediate guide plate.

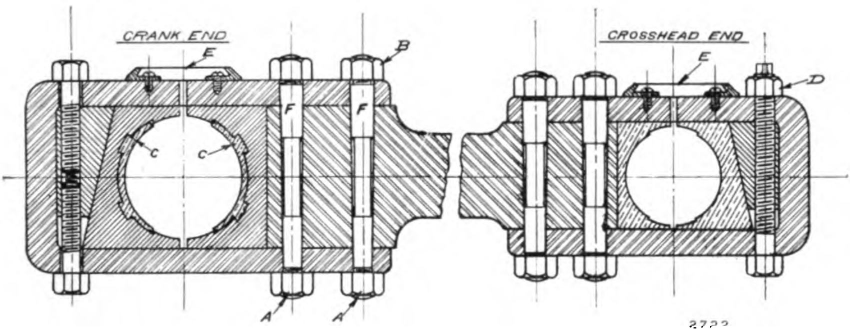


Figure 4--Connecting Rod

CONNECTING RODS

The connecting rod is of the strap end type, with liberal length of strap extending over the butt ends of rod.

The fastening of strap to the rod is by means of taper stud bolts, provided with a fine thread on each end to give good clamping power and insure a rigid connection.

To dismember a rod (note that stud bolts are put in with large part of taper at top side of strap) remove the stud bolt nuts "A", Figure 4, on under side of strap on end of rod which it is desired to disconnect, then screw down nuts "B" on top side. This will draw stud bolts up and free them so that they may be removed by hand.

In reassembling rod leave off top nuts "B", insert stud bolts "C" from top side and drive home with soft hammer or ordinary hammer and a piece of hard wood, then put on nuts "A" and make up tight, next put on nuts "B" and set up hard.

On the smaller sizes of machines both crank pin and crosshead pin bearings are made of special hard anti-friction bearing metal. On the larger sizes the crank pin box is a malleable iron casting lined with anti-friction metal as shown at "F" on cut, and in case of lining wearing out, the box may be refilled.

The adjustment is by means of taper wedge and screw. On the crank end two screws are used; if loose, to make adjustment slack off on top screw and tighten up on lower, or vice versa, if too tight.

On the crosshead end one screw is used; to make adjustment for loose bearing, slack off nut "D", then by using a wrench on square on upper end of screw turn the screw counter clockwise and then set up nut "D". To make adjustment for tight box, slack off nut "D" and then turn screw clockwise and set up nut "D". In making these adjustments, good judgment is necessary to insure satisfactory results.

On the upper side of the rod, and directly over the center of both bearings, small basins "E" are provided to retain the oil delivered by the lubricating system.

STEAM PIPING

The steam piping should drain toward the compressor throughout its whole length. This is important, for if the pipe contains low spots or pockets, where water could accumulate, a sudden increase in the demand for air, with a more rapid flow of steam through the pipe, might cause it to carry the entrained water with it to the cylinders and do serious damage. The use of a steam separator is recommended, particularly if the compressor is located at a considerable distance from the boiler. This would furnish drier steam to the compressor, increase the economy of the machine and be a safeguard against water being carried into the cylinders. Place a stop-valve where the steam pipe branches from the main line. This is for convenience when making repairs or repacking or regrinding the throttle-valve, and may also be used to shut down the compressor in the event of an accident to the regular throttle-valve.

In connecting the governor to the steam arch, be sure that the governor shaft is in line with the main shaft of the compressor so that the chain will run true on the sprockets.

A drain should be provided in the steam pipe on the boiler side of, and as close as possible to, the compressor-throttle. The steam pipe should all be covered with some form of non-conducting material such as asbestos or mineral wool.

Upon the completion of the steam piping it should be thoroughly blown out with a good pressure of steam. This should be done before making the final connection to the compressor at the governor; or, if the piping was begun at the compressor end, it should be especially disconnected for the purpose. There is usually an accumulation of chips and loose scale in the piping, which will be removed by the escape of the steam under pressure; this insures clean steam chests and cylinders free from any grit which would be apt to damage the valves and the seats.

EXHAUST PIPING

Best practice advocates the laying of the exhaust piping beneath the floor, running it to the side of the compressor-room, then vertically to the atmosphere. The horizontal portion of the exhaust pipe leading to the riser should pitch slightly toward it. Its connection to the riser should be made with a tee or an elbow with a tapped hole in its heel to provide a drain for the condensed steam. If the compressor has compound steam cylinders the steam receiver must be properly drained; an opening is provided for this purpose at the end of the horizontal portion underneath the low-pressure cylinder. This should always be opened before starting the compressor, and steam turned into the receiver through a by-pass valve. The receiver, as well as both the steam cylinders, should be thoroughly warmed by steam before starting the compressor.

If a condenser is used the main exhaust pipe will be connected to it, but there should also be an opening to the atmosphere provided with an automatic relief-valve. A stop-valve should be placed in the exhaust pipe between the condenser and the relief-valve. All of the exhaust piping should drain toward the condenser.

STEAM VALVES

All Type X compressors with compound steam cylinders of the slide-valve type are equipped on the high-pressure side with a balanced steam valve; also, on all Type X compressors with duplex steam end, the main valve is of the balanced type.

Machines in sizes up to 14″ stroke are equipped with plain "D" Steam Valves, sizes 14″ stroke and larger have Meyer adjustable cut-off valves.

Figure 5 illustrates the construction of the balanced valve used on the 14″ stroke compressors and upward. The main slide-valve and cut-off valves are of the Meyer type. The top plate is machined to form a chamber for the balance ring which bears on the under face of the steam chest cover, forming a steam-tight joint. The space, inside of balance ring, communicates with the exhaust port.

When the machine is at rest or starting, contact is maintained between the balance ring and the cover by means of four springs, placed in the top plate under balance ring. As soon as the compressor is in motion the steam pressure acting on its face maintains the contact. An oblong shaped nut is fitted into a chamber in the center of the main valve and with the valve stem, which is screwed into it, forms a driver for the valve.

The cut-off valves are operated by the cut-off valve stem, which is screwed into two nuts, one of which is provided with a right-hand and the other with a left-hand thread of equal pitch.

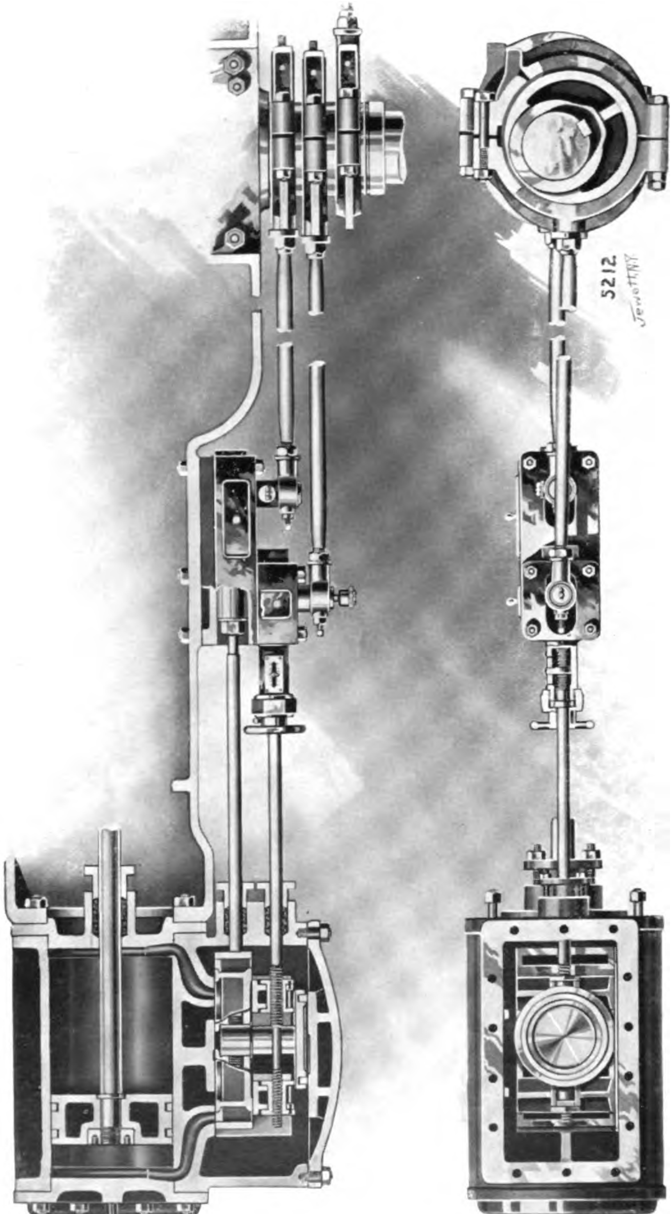


Figure 5—Construction of Meyer Cut-off Valve

The inner or left-hand thread is cut on the full diameter of the cut-off valve stem, and the outer or right-hand thread is sufficiently reduced in diameter to allow the left-hand thread nut to pass over it.

The valves are set by trial and then secured by a locking piece fitted into the fork of the valve and fastened by a riveted pin. Adjustment for long or short cut-off is obtained by turning the hand wheel, which is secured to the cut-off valve rod. The position of the point of cut-off, relative to piston travel, is shown by an indicator, which is a section of a nut with a thread of the same pitch as the thread on cut-off valve nuts, and fits on a similar thread on rod.

On sizes of machines heavy 20″ stroke and larger the construction is somewhat different, the cut-off adjusting wheel being arranged on outer end of steam chest. The above description, however, will practically cover these compressors.

AIR PIPING

The compressors are provided with flanges for inlet pipe connections so that the supply of air may be drawn from the coolest and cleanest possible source. The conduit leading to the compressor should be at least double the size of the air inlet pipe. It may be constructed of wood, of tile or of iron pipe, and sometimes is built of brick. Brick or concrete should be avoided because the pulsations of air loosen the sand and grit, which is thus drawn into the cylinders and valves. Some very serious complaints have been traced to this cause.

Care should be taken when putting in the suction pipe and constructing the conduit to see that nothing gets into them which might be drawn into the compressor. The entrance should be covered with a screen to prevent any extraneous matter from getting into the pipe and the cylinder which might injure the machine.

The advantage of supplying cool air is well worth considering; for every five degrees reduction in the temperature of the air entering the compressor there is a gain of about one per cent. in its volumetric efficiency.

The pipe to the receiver should be the full size of the compressor discharge opening, and should have as few turns as possible. The use of long-turn fittings is highly recommended. The receiver should be provided with a safety-valve regulated to blow at a pressure about five pounds above that at which the pressure regulator, attached to the governor, is set to operate; and this safety-valve should be opened frequently to see that it does not become "stuck" and inoperative. The regulator should be connected by a ¼″ pipe to the top of the air receiver. Under no circumstances must this pipe be connected to the delivery pipe from the compressor, as the pulsations in it even at

somė distance from the compressor, will cause the regulator to work unsatisfactorily. There should be a valve at the bottom of the receiver for draining the moisture and oil precipitated from the air. The receiver should be located in as cool a place as possible, that most of the precipitation may occur at this point where any water or oil may be readily drained. If for any reason the receiver is placed where liable to freeze, the safety valve must be piped back into a warm room.

If for any reason a stop-valve is inserted between the compressor and the receiver, a pop-valve should be connected in the pipe line somewhere between this stop-valve and the compressor to prevent an accident to the compressor in case the machine is started with the stop-valve closed.

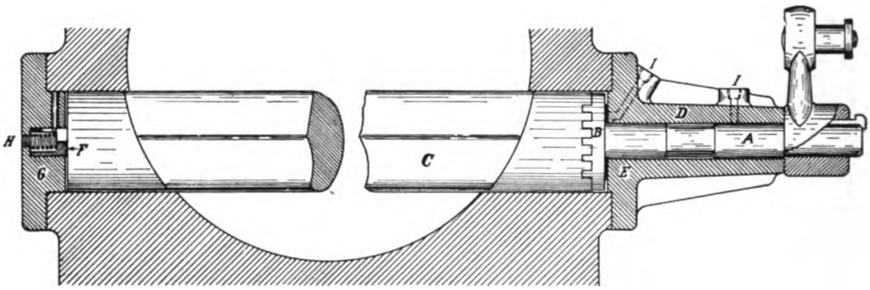


Figure 6—Air Inlet Valve

AIR VALVES

The inlet valve on both air cylinders are of the Corliss type. The valve-stems are self-packing. Fiber washers are placed between the inside faces of the valve-stem brackets and the heads of the valve-stems, a thrust arrangement is provided in the plain bonnets, which holds the faces in contact and makes a tight joint. If the fiber washers wear out they may be replaced at slight expense.

This valve, illustrated in Figure 6, is designed to reduce clearance to a minimum. It is made of cast iron and is operated by a steel stem "A", which has a large flange "B", provided with a series of tongues on its inner face, machined to match with grooves on end of valve "C". This arrangement makes a very effective drive.

Valve bonnet "D" is of the stufferless type, the stem being made self-packing by means of a fiber washer "E". Contact is maintained between faces of fiber washer and face of valve stem collar, also bonnet face, by means of a spring and thimble "F" in back bonnet "G". Efficient lubrication for the valve is provided through the back bonnet at "H", and the lubrication of the valve-stem in the front bonnet is similarly cared for at "I".

The outlet valves are of the direct lift type. They should be removed at least once a month for cleaning and examination. If the service is more than ordinarily severe more frequent inspection is advisable. A patented copper gasket is used under head of outlet valve bonnet and, by applying a mixture of graphite and cylinder oil on the threads of the bonnets before putting them in place, will allow them to be removed without difficulty at any time. It is well to keep an extra set of clean outlet valves to replace those in service whenever it is desired.

CIRCULATING WATER

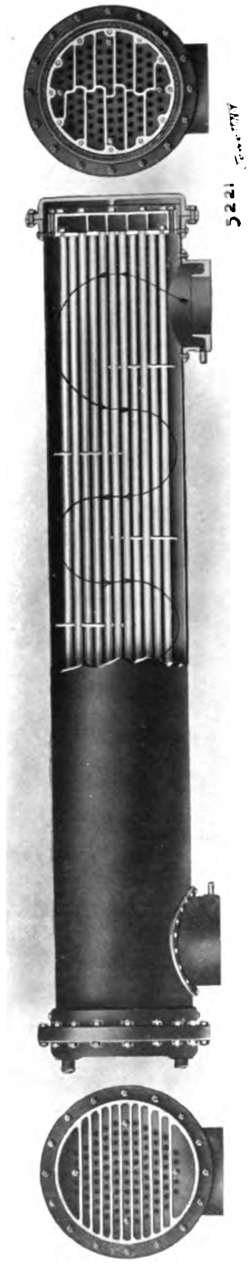
A liberal supply of cooling water should be furnished to remove the heat generated by compression, which not only would greatly increase the power required to compress the air, but also render the cylinder lubrication less effective. If water is costly and must be used economically it may be utilized for other purposes after leaving the compressor.

If the circulating water is dirty, mud will be deposited in the cylinder-jackets and intercooler, tending to interfere with the proper cooling of the air, and will ultimately choke off the flow of jacket water entirely; under these conditions precaution should be taken to keep the water passages clean. Usually, the mud may be removed from the jackets through openings, exposed by taking off the outer air-heads. The intercooler may be cleaned by taking out the nest of tubes, removing the plugs found in the back heads and flushing with water. If necessary, the heads at both ends may be removed and a cleaning rod used.

Whenever the compressor is exposed to a freezing temperature while not in operation, great care should be taken to have the jackets and intercooler thoroughly drained of water, in order to prevent injury from freezing. Openings will be found on the under side of the cylinder for draining the jackets, and at under side of the water-heads of the intercooler for draining the nests of tubes.

Valves must never be placed in the outlet water pipes, but the flow should be regulated by throttling the inlet to the jackets. This precaution will prevent injury to the compressor from excessive water pressure. It is well to have the overflow from the jackets lead to an open drain, so that the water circulation may be seen. A good arrangement is to have a funnel in plain view above the floor line at the connection leading to the drain.

On sizes up to the heavy 16″ stroke, the circulating water is piped separately for each side of the machine, the water being first led to the intercooler, then to the outer cylinder head, and then through the jackets of the cylinder to the frame-head; the final discharge being from the frame-heads into the funnel which should be piped to drain.



Intercooler for Larger Sizes of "Imperial" Type X Compressors

On the heavy 16″ stroke and larger sizes the intercooler and jackets have independent water connections. A separate valve should be provided to control the supply to each side.

INTERCOOLER

On compressors having compound air cylinders an intercooler is used. The intercooler consists of a number of small galvanized iron pipes, around which the compressed air circulates in thin streams as it passes from the low-pressure to the high-pressure side of the compressor. Baffle plates are so distributed in the shells as to force the air across the water pipes several times that it may be reduced to about its initial atmospheric temperature. The cooling of the air precipitates a considerable amount of moisture, which is deposited in the shell of the intercooler and which should be frequently removed. Tapped holes are provided for this purpose on the under side of the intercooler. The most satisfactory way to take care of this precipitation is by means of a float trap. Any reliable make of trap will be suitable, and the smallest size obtainable will be found amply large for the purpose. (An expansion trap, the operation of which depends on variations in temperature, would not work.) On a small-sized compressor the moisture may be satisfactorily taken care of by providing a little receiver constructed of 6″ or 8″ wrought iron pipe, with caps at either end, and located at some convenient point under the intercooler, the shell on the intercooler is tapped in two places, one at each end, to which connection may be made for the moisture collector. This receiver may be blown out at intervals, and, under ordinary conditions, would not require very frequent attention.

On the heavy 16″ stroke Imperial compressors and upwards the arrangement of the intercooler is above and crosswise of the air cylinders. The free air is led to the bottom of the low-pressure cylinder through an opening in the foundation. The outlet passage is at the top of the low-pressure cylinder, and the inlet to the high-pressure cylinder is on the top also. Pockets are provided to collect the water of condensation, and must be drained at suitable intervals. This construction eliminates the accumulation of moisture and prevents possible damage to the high-pressure cylinder.

The pressure of the air in the intercooler should be a certain amount for a given terminal pressure, and any increase in this pressure will indicate that the valves in the high-pressure cylinder are not working properly.

The intercooler passage is therefore provided with a small pop safety-valve, set a few pounds above the normal intercooler pressure. The purpose for which this valve is intended is not to relieve entirely the excess of pressure (for its capacity is not sufficiently great for accomplishing that), but to call the attention of the attendant to the fact that something is wrong, *and when the valve blows investigation of the cause should be made at once.*

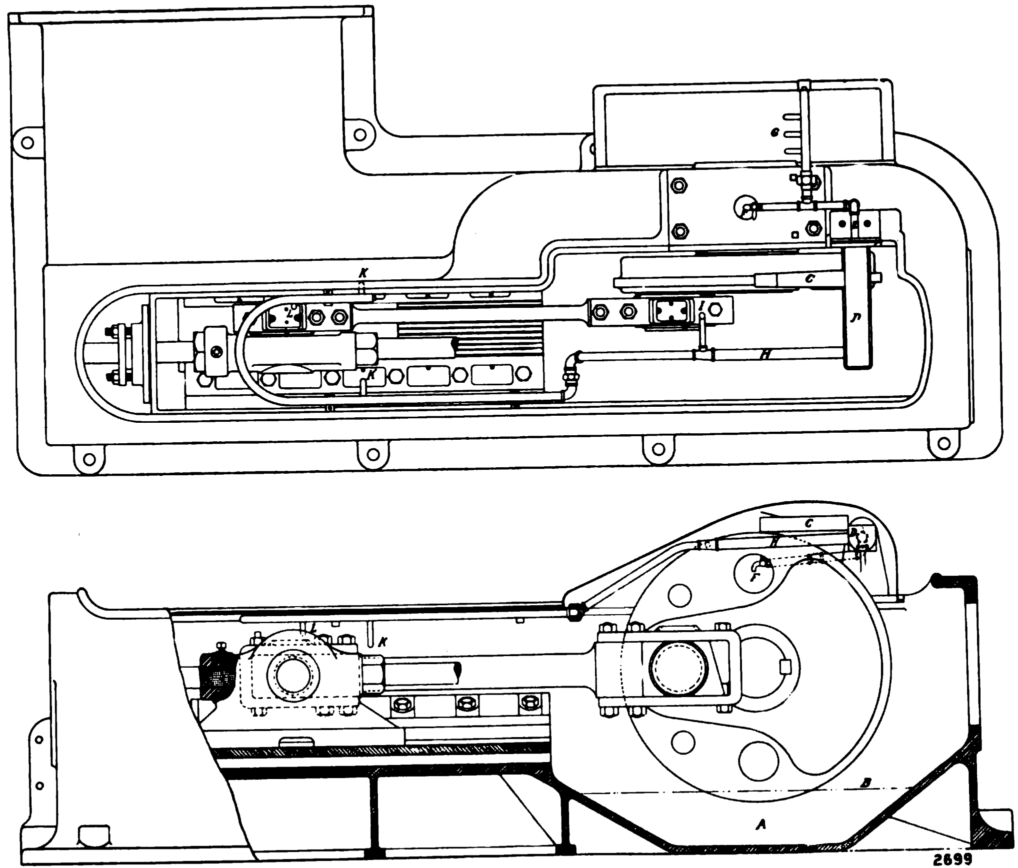


Figure 7—Bath Lubricating System on "Imperial" Type X Compressors

PRELIMINARY TO STARTING

The compressor having been set and piped in accordance with the foregoing, the following matters should be looked after before starting:

The first thing to be done is to have the crank-cases, oil-guard, valve-rod, slide-guides, oil-pockets and all pipes and parts pertaining to the oiling system thoroughly cleaned out. An accumulation of dirt and cinders is unavoidable in railway shipment, and more particularly so with the Imperial machines, as they must be shipped on open cars. Care is taken to make everything tight before shipment, but it is practically impossible to keep all the dirt out. If this is not removed it tends to clog the oil passages and may also injure the bearings if carried into them by the oil. The entire upper coverings of the crank-cases and the upper parts of the eccentric shields should be removed and every portion of their interiors thoroughly wiped out, and all oil passages blown out with a jet of air or a good bellows.

LUBRICATION

When the cleaning is finished and the various parts replaced, a quantity of high-grade, medium body engine oil should be poured into both crank-case basins "A", Figure 7, sufficient to submerge the crank-discs about one and one-half inches. The height is represented by line "B".

When the machine is in operation, oil is carried around on the crank-disc periphery from the basin "A", and is collected by a spout "C", which in turn delivers the oil to a receiving box "D". From this box the oil is led through pipe "E", to the main bearing at "F" and to the eccentrics at "G", while the pipe "H" leads oil to crank pin at "I", to the crossheads and guides at "K" and also to crosshead pin at "L". All the oil delivered to the system is returned to the basin "A"; the oil may thus be used repeatedly. On the 20″ stroke and upwards the connections, which make up the lubricating system, are attached to the compressor frame. All sizes are provided with openings in frame, crank-case and eccentric-case covers for the inspection of the lubricating system while the compressor is in operation.

The lubricators on the steam cylinders should be filled with heavy cylinder oil of good quality. A generous quantity of oil should be used in the steam cylinder, as the steam has a continual tendency to wash it out.

When the machine is first started, we should advise that well-rendered tallow be mixed with the oil and fed to the steam cylinders in the proportion of about one pound of tallow to one gallon of cylinder oil. The use of this mixture should be discontinued after a few weeks.

The air cylinders are supplied by sight-feed lubricators on the inlet valve bonnets. These cylinders should be lubricated with the best grade of mineral

oil, of light body and high flash test. It must not be of a coking nature, for if it is it has a tendency to carbonize on the inside surfaces of the air-heads and valves, and not only prevents the latter from proper action, but is also frequently the cause of accidents. The air cylinders require but a very small quantity of oil, and after the machine has been running long enough for the cylinders to acquire smooth and polished surfaces, two or three drops per minute will be found a sufficient amount to keep each cylinder, with its valves, in satisfactory condition. Fill the pockets of the valve-rod slide-guides with engine oil, and the various grease cups with good cup grease of medium stiffness.

STARTING

Compressors that are shipped assembled require no adjustment in any of the parts before starting, as they are operated for some time previous to shipment under full steam and air pressure, and properly adjusted before they leave the shop. It is well, however, to make a careful examination to see that nothing is loose or has been tampered with during shipment.

Turn the machine over a few times by hand to see that it works freely and that everything is clear. This is an important precaution, as accidents have resulted by the admission of steam into a newly erected machine without first having turned the flywheel through at least one revolution to see that everything is clear.

After the compressor is in proper condition, open the various feeds on the steam and air cylinder lubricators and oil cups. Screw up the grease cups enough to force a small quantity of grease into each of the various bearings on which they are placed. See that the cylinder drains are open; then open the throttle a very little and allow all the water to be blown out of the steam pipes and cylinders. After blowing the steam through for a few minutes so as to thoroughly warm up the cylinders, open the throttle a little wider and the machine should start. Allow it to run slowly for a short time, and then bring it up to its working speed by closing the cylinder drains, and see that the governor controls it properly. The compressor should be run for a while with no pressure on the air receiver, with either the safety-valve raised or some valve opened to allow the air to escape. All of the feed pipes of the oiling system should be examined to see that the oil is flowing freely through them and the various bearings watched to see that they remain cool. After a little while, if everything is working satisfactorily, the valve which is allowing the air to escape may be closed and the machine allowed to perform its regular work. The pressure regulator on the governor should be adjusted so as to throttle the supply of steam at a pressure slightly in excess of that at which the compressor is to operate; this pressure is indicated by the gauge on the receiver. The compressor should not be permitted to come to a standstill and then to start

again when the pressure falls, for if it is stopped very long, water will accumulate in the steam cylinders, which will be a source of danger in the event of its quickly starting up again.

The weight arm on the pressure regulator is so shaped that the pressure required to lift it continually increases as the weight rises; thus the compressor will decrease in speed when the limiting pressure is reached, and continue to decrease to the point where its output of air does not exceed the demand.

A set-screw is provided to limit the movement of the governor arm, which should be so adjusted as to prevent the steam from being entirely cut off. This keeps the compressor from coming to a full stop and the small amount of surplus air may escape through the safety-valve on the receiver.

The compressor should be closely watched at the start, the oil in the crank-cases receiving particular attention. Even though the compressor may have been carefully cleaned there is sure to be more or less dirt remaining, which will be washed out by the circulation of the oil. All of this dirty oil should be removed through the openings on the lower sides of the eccentric shields. The bottoms of the crank-cases should again be wiped out and all sediment removed. A fresh supply of oil may be put in, which will remain clean for a longer time, but when this also becomes dirty, it should be removed. (*The oil removed may be filtered and used again.*) After the compressor has been running for a while it should not be necessary to change the oil oftener than once a month.

ADJUSTMENT

We first wish to call special attention to a point regarding the adjustment of a machine using the bath-system of lubrication. Owing to the large quantity of oil that is continually flowing, the bearing may be run much looser than is possible where only a small amount of oil is supplied, as the oil serves as a cushion and prevents the knocking that would otherwise be present. The bearings on these machines, and specially the main bearings, are very large, and could be so tightened as to result in unnecessary friction, while the oil would carry off the heat fast enough to prevent the bearings from becoming very warm. Unless this fact is taken into consideration the bearings are apt to be made much tighter than is required, which will result not only in loss by friction but also in a stiff and sluggish action of the machine. All bearings, therefore, should be run as loosely as possible without knocking, for if a bearing does not run hot it does not necessarily follow that it is adjusted for producing the best possible results.

The adjustment of each main bearing is effected by means of a wedge. This wedge is held in position by a stud and two set-screws. The stud is in the

middle of the wedge and passes up through the main bearing cap, where it takes a nut for drawing the wedge upward. There are two set-screws, one at each end of the wedge, which work in opposition to the stud. Each bearing should be adjusted as follows: Loosen the middle stud, then screw down both set screws equally hard, so that the bearing is forced tight against the shaft; then back off the set-screw an equal amount and tighten up the nut on the stud, drawing the wedge tight against the two set-screws.

Standard wedge adjustments are provided on the connecting rods. After considerable wearing of the brasses the pistons may be a little nearer one end of the cylinders than the other, but the clearance may be readjusted by unlocking the piston rods where they are screwed into the crossheads, removing the cylinder heads, and screwing the piston rods in or out, as may be required.

The eccentric straps are so arranged that adjustment is required only at the top side, which is the more accessible. The joint at the lower side is arranged to swing. The adjustment at the upper side is effected by the removal of liners, so as to allow the parts to be drawn closely together.

VALVE SETTING

Under no circumstances should the valve setting be changed. The correct setting of the valves has been carefully determined by experiment, and the compressors are sent out with the valves properly adjusted. To obviate any possibility of the eccentrics changing position, they are keyed in place. It will be advisable to write the Ingersoll-Rand Company direct should the valves for any reason seem to require adjustment.

THE "AIR-BALL" GOVERNOR

This device is at the same time a speed regulator or governor and a means for holding a constant air pressure in the receiver. It consists of a special balanced throttle valve, the spindle of which is connected to a fly-ball governor driven by a chain from the engine shaft. This throttles the steam supply when the engine speed exceeds the desired limit.

At one side of the governor is a small air cylinder, the piston of which presses against a lever on which is a sliding weight. This cylinder is under receiver pressure. The inner end of the weighted lever connects with the spindle of the balanced throttle through a link which makes the action of the small air cylinder independent of the fly-ball governor, so that when the pressure in the receiver exceeds that for which the governor is set, the weighted lever is raised and the balanced throttle closed to a point which admits steam enough to turn the machine over at the speed necessary to supply a volume of air equal to that being drawn from the receiver.

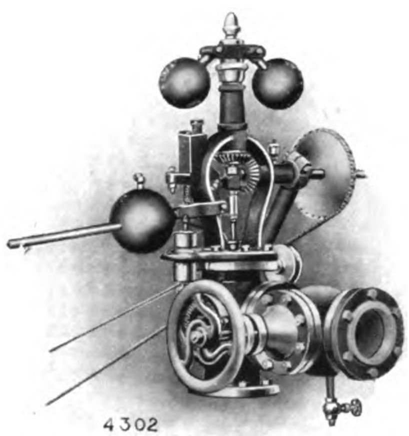
If from any cause the air pressure in the receiver drops, the weighted lever is allowed to drop, by the decrease of pressure in the small cylinder. This opens the throttle, admitting more steam to the engine. If an air pipe should break or too great a demand is made upon the compressor, keeping the air pressure down so that the air piston does not work, the engine speeds up to a point where the centrifugal governor partially closes the throttle and brings the engine back to its rated full speed or the speed for which the governor is set. In this way it is possible to operate the compressor discharging into the atmosphere and racing cannot occur.

Adjusting screws are provided so that the governor can be set to hold the compressor at any desired speed or pressure.

OPERATION OF GOVERNOR

Connect opening in bottom of governor air cylinder with air receiver.

The desired receiver air pressure can be obtained by moving the weight on the lever.



Standard "Air-Ball" Governor
used on "Imperial" Type X Compressor

If it is desired that the governor should not stop the compressor when the maximum pressure is reached, adjust the screw above lever until the engine will just turn over when the desired air pressure is obtained; then set jam nut so the screw cannot be moved.

The maximum speed of compressor can be changed by adjusting the inside speed screw; the outside speed screw is adjusted at the factory and should *never* be *changed.*

Oil all revolving parts on governor and particularly the toe plate in head that the governor arms press on.

In ordering repair parts always give the shop number of the governor, which is stamped on the side of the head.

THE MASON-HENRY PRESS
SYRACUSE AND NEW YORK

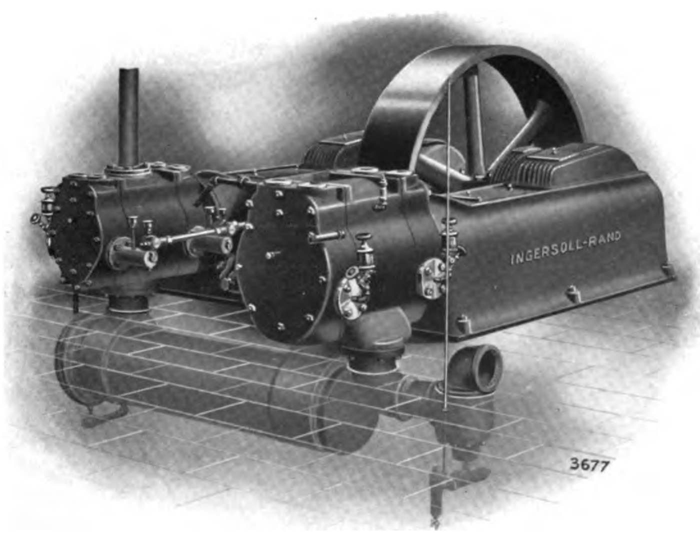
"IMPERIAL XB"
DUPLEX POWER DRIVEN
COMPRESSORS

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Form No. 3112 September, 1910

THE "Imperial XB" Compressor is an "all-around" machine, moderate in first cost, low in operating and maintenance charges, compact in design, as nearly automatic as possible, and thoroughly reliable under whatever conditions of service. The diversity of fields in which these machines have found successful application is evidence of their adaptability to every duty. They are suitable for mine, tunnel, quarry, and contract plants; shop and foundry equipments; air power plants for railway repair shops and for switch and signal service; air lift, "Return-Air," and displacement pumping systems; and general industrial applications of compressed air.



" Imperial XB-2 " Two Stage Compressor with Underneath Intercooler and " Imperial Unloader "

A Unit Construction

The "Imperial XB" compressor represents a unique design among compressor types. While belonging distinctly in the duplex class, the heavy and substantial main frame carrying all other parts makes the machine a solid and self-contained unit, as much so as a straight line machine. The air cylinders, being bolted to this frame, are in no way dependent upon the foundation for correct alignment. The bearings are an integral part of the frame. The driving wheel is hung centrally both as to length and breadth of the machine. One advantage of this arrangement is that the weight of the machine is evenly distributed over the foundation.

Accessibility

When the compressor is in operation the driving wheel is practically the only moving part visible. Cranks, connecting rods, crossheads, eccentrics are all enclosed in the casing of the base, yet every part is readily accessible by removing covers from the casing. It may be well to emphasize the fact that the "Imperial XB" is accessible *While Running*. The system of lubrication is a flood system, so that the cover plates can be removed without any danger of oil being thrown out. The "Imperial" in point of accessibility has all the advantages of the open type of machine with the attendant advantages of enclosed automatic lubrication. The bore of either cylinder can be exposed for inspection by simply removing the outside head, without disturbing any other part of the machine.

Duplex Advantages

The many recognized advantages of the duplex construction in power driven air compressors are fully embodied in "Imperial" machines. A few of these may be mentioned here: a balanced construction, with quartered cranks effecting an equalization of efforts; easier duty on the belt; the reduction of structural stresses by this balanced construction; the ease with which the air cylinders can be compounded, with all the attendant economies and without any increase in the number of working parts.

Ease of Installation

The solid box bed of the "Imperial" obviates the only objection ever rightfully urged against the duplex type. It makes the machine practically independent of its foundation, and this, together with the compactness of the design, permits a simple, small, and therefore less costly foundation. The installation of one of

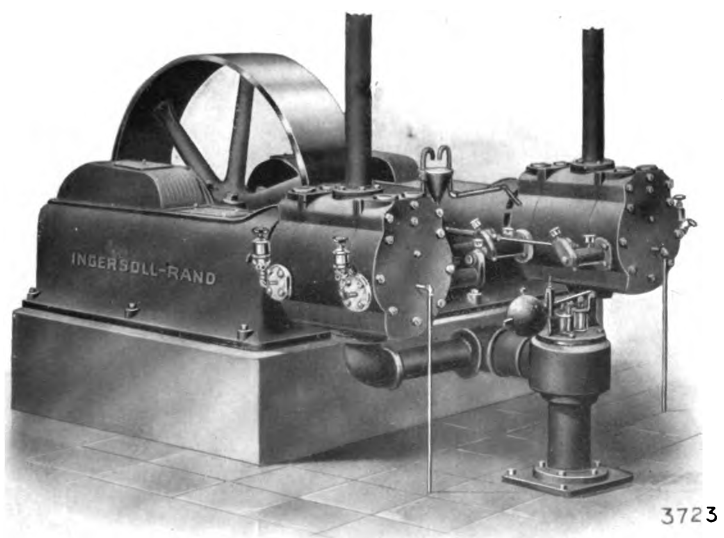
these machines consists simply in placing it on the foundation, leveling up, tightening the anchor bolts, grouting the joints, and connecting up the piping. There is no "lining up" in the ordinary sense.

Large Air Capacity

The "Imperial XB" has a greater air capacity per unit floor space than most other power driven compressor types. This is due directly to the higher speeds possible in this design, and secondarily to the exclusive features of the design itself. Examination of the tables on pages 14 and 15 show a rotative speed which has been demonstrated in hundreds of instances—in many cases after years of heavy duty—to be thoroughly practical and safe.

Some Exclusive Features of Design

This unusual fact is to be credited to several exclusive features of design, among which the following may be emphasized: the massive, well-braced structure; the unusually generous bearing surfaces; the exceptionally thorough lubrication, automatic and ample at all speeds; the mechanically actuated air intake valves with large, direct passages; the light-running, almost noiseless discharge valves; and the care bestowed upon every detail of construction.



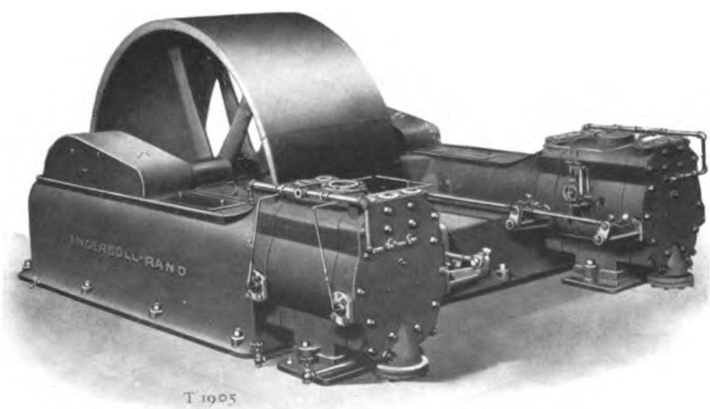
"Imperial XB-1" Duplex Single Stage Compressor with "Choking Controller"

The Lubricating System

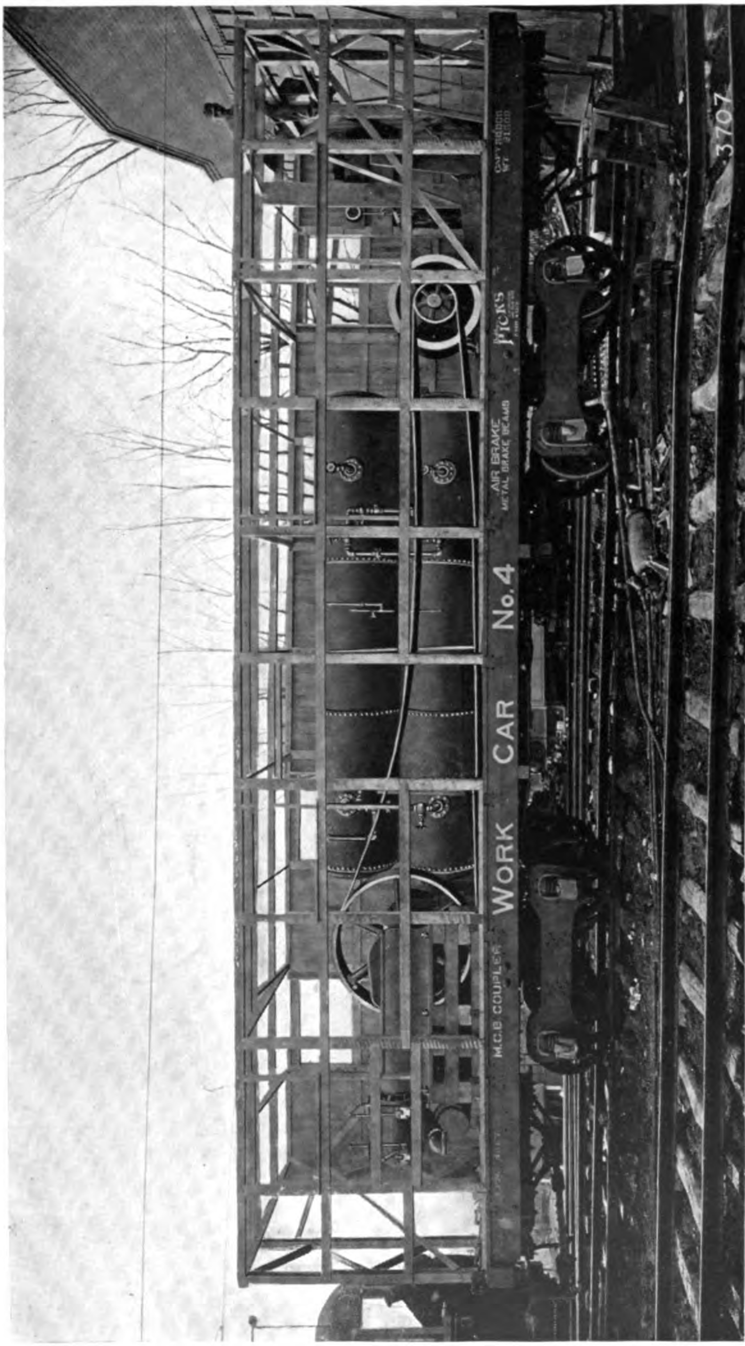
The system of lubrication is unique and unsurpassed. The crank disks, dipping into an oil chamber in the main frame, deliver oil by means of a wiper pan to pockets or reservoirs from which it flows by gravity to the main bearings, eccentrics, crank and cross-head pins, crosshead guides and piston rods, which are literally flooded with oil at all speeds. It is impossible for any bearing to run dry so long as an adequate supply of oil is maintained in the crank basin. The overflow from the bearings is returned to the crank chamber and used over again. All running parts are fully enclosed, making the "Imperial" type the most cleanly compressor on the market. The cylinders have sight-feed oilers and the bearings of the valve gear are fitted with oilers and grease cups.

Economy of Oil

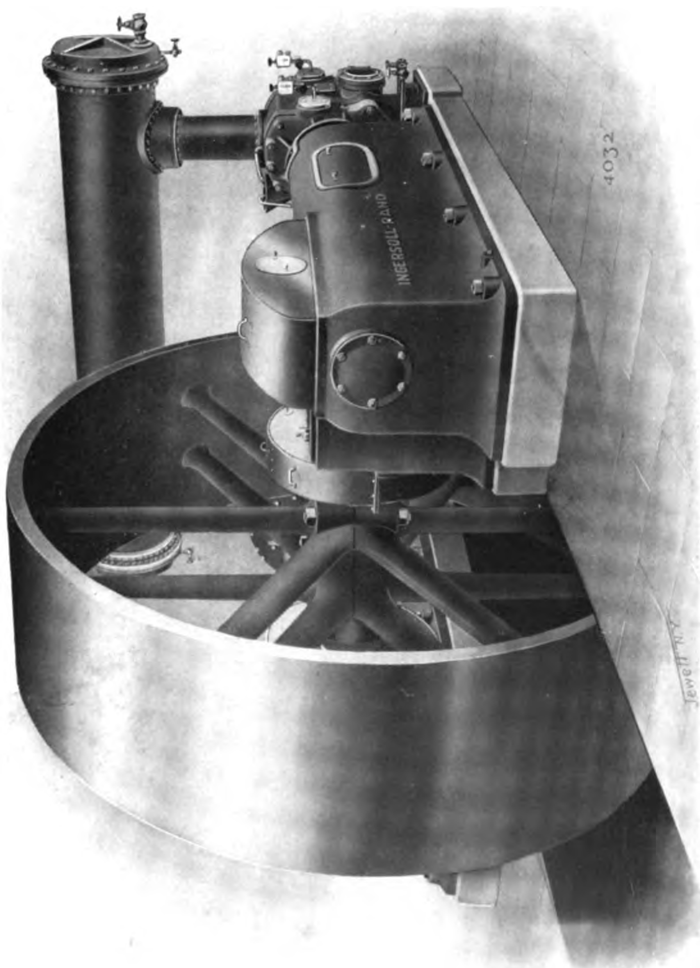
This system of lubrication, characteristic of all "Imperial" types, results in a marked economy of oil. As an instance of this, one user of this type of machine has reported that he has had in operation a 12-inch stroke steam driven "Imperial" type of compressor, the total oil consumption of which, for a period of eight months' operation, eighteen hours per day, was only ten gallons. This example illustrates not only the oil economy of the machine, but also the superior workmanship throughout every part.



A Standard "Imperial XB-1" Duplex Single Stage Compressor, built for a Southern Gas and Electric Co.



"Imperial XB-2" High Pressure Two Stage Air Compressor, Mounted on a Car, Used by a Cleveland Street Railway Company
for Charging its Air Brake System



24-inch Stroke "Imperial XB-2," Built for a Western Mining Company

An Adaptable Type

The sensitive and easy-acting regulating devices and the novel system of lubrication make this compressor as automatic in action as a machine of this type can be. These features, combined with the large air capacity, have made the "Imperial" type one of the most popular machines for all classes of service, but particularly for conditions demanding great capacity and perfect reliability combined with minimum dimensions and automatic operation.

Standard Classifications

The "Imperial" line of compressors is built in both steam and power driven types, but only the latter is treated in this pamphlet, two separate publications (Nos. 3111 and 3013) being devoted to the former. Tabulated and detailed specifications are given on pages 14 and 15, but at this point the following classifications are to be noted, giving the standard symbol which designates each modification of the basic type.

"Imperial XB-1"—Duplex Air Cylinders.

"Imperial XB-2"—Compound Two Stage Air Cylinders.

The Driving End

Standard "Imperial XB" Compressors are equipped for belt drive. The driving wheel is properly proportioned as to diameter and belt face, and its weight affords the necessary flywheel effect for smooth running. Grooved wheels for rope drive can be furnished where the requirements demand it.

Special electric driven "Imperial XB" outfits have been built, the motor and compressor being a unit, with either gear or silent chain drive. The Company, however, does not wish to encourage this practice, as these two methods of drive are satisfactory only in small capacities. Except where a very compact installation is essential, the Company always urges the standard machine with belt or rope drive as promising more satisfactory sustained results.

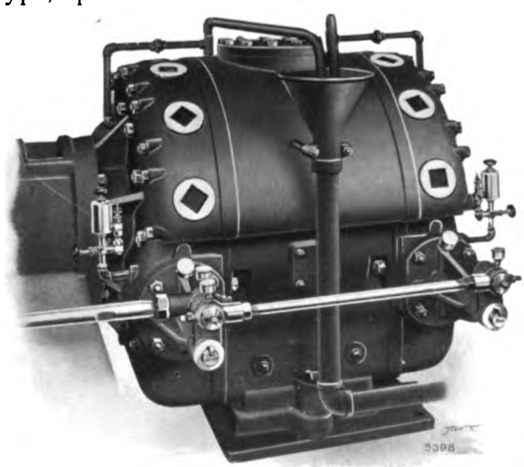
A recent development, however, following upon the increasing utilization of electric power for air compression, is the direct-connected "Imperial" with the motor on the compressor shaft. This, however, makes practically a new type, which is designated as "Imperial XE" and to which a separate pamphlet (No. 3014) will be devoted. These are splendid high-speed machines, representing the most advanced principles of pneumatic and electrical design.

Air Cylinders

The air cylinders of all "Imperial" Compressors are designed for maximum compression efficiency. Barrels and heads are water jacketed, the latter being hooded for the admission of cool, clean air. Both inlet and discharge valves are in the cylinder heads. The smaller compressors, up to 16-inch stroke, have overhung cylinders. On larger sizes the air cylinders are supported on a strong foot-piece resting upon a sole-plate on the foundation, and may be slid away on this sole-plate when it is necessary to detach the cylinder from the frame.

Air Intake Valves

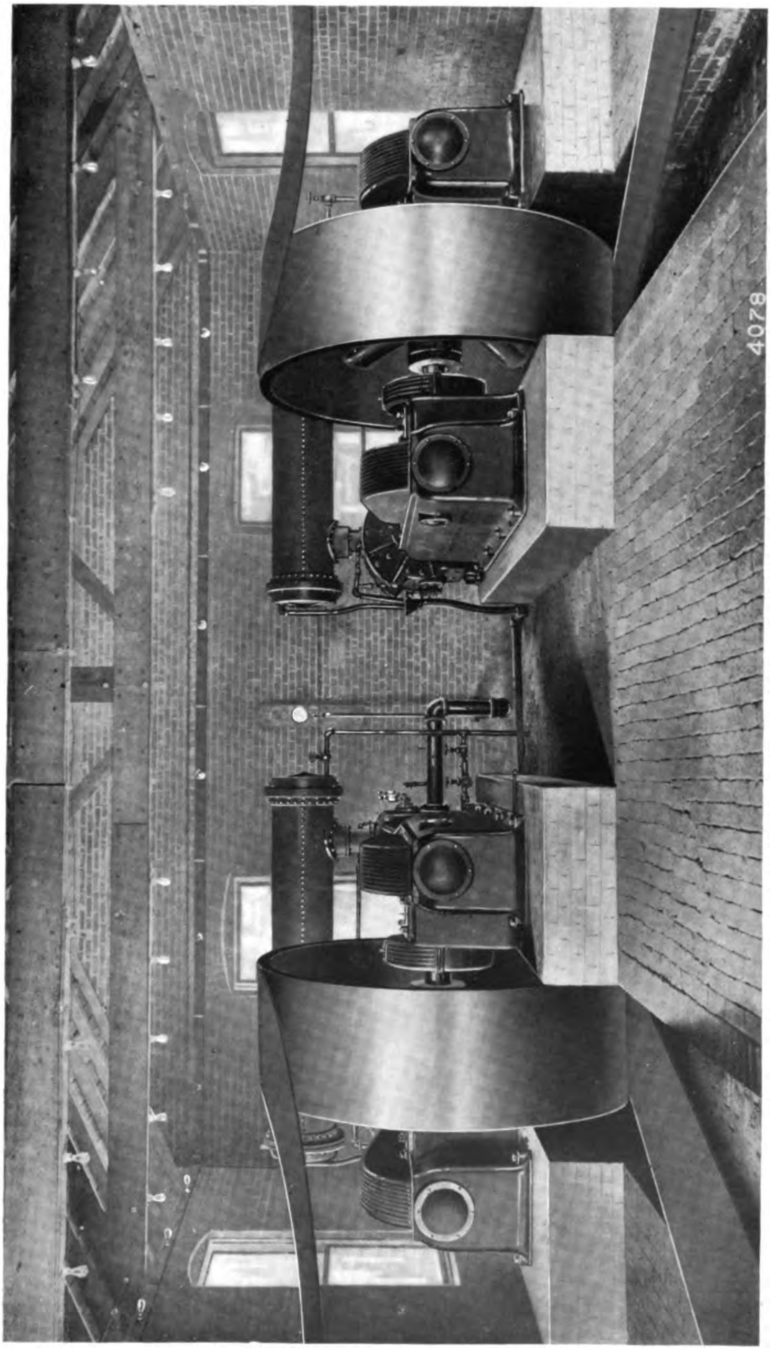
The air intake valves are of the well-known "Imperial Corliss" type, operated from eccentrics on the main shaft. These valves are of unusually large diameter and provide the shortest and most direct passage for the entering air, with the minimum of clearance. The working pressure is evenly distributed over the entire valve surface, which is almost exactly a half circle; and this pressure being always central, there is no tendency to wear either the edges of the valve or the surfaces with which they come in contact. The valve adjustments are so fixed that they cannot be disarranged by an incompetent attendant.



A Typical "Imperial" Air Cylinder, with "Imperial Corliss" Inlet and "Imperial Direct Lift" Discharge Valves

Air Discharge Valves

Air discharge valves are of the "Imperial Direct Lift" pattern. Their lift is ample and the port passages are short and free. Springs are of large diameter and close pitch, with sufficient tension for their work, yet imposing no undue load upon the machine. The spring absorbs the shock at the end of the lift, reduces the noise of operation, and gives a longer life to the mechanism. In fact these discharge valves are almost noiseless in operation.



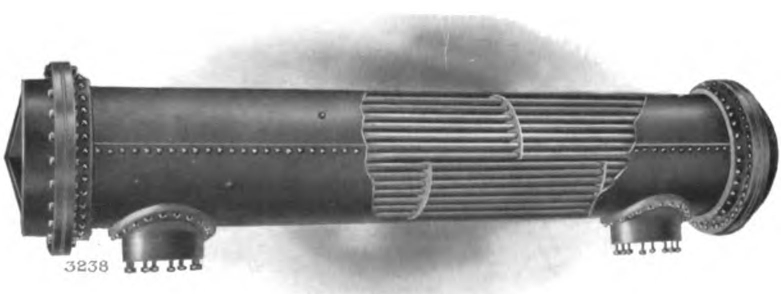
Two 20-inch Stroke "Imperial XB-2" Compressors, Belt Connected to Electric Motors, in the Blanco Sub-Station of the Cowanshannock Coal and Coke Company

Compound Air Cylinders

The economical advantages of stage or compound compression are so generally understood that they need not be discussed here. The best practice adopts single stage compression for pressures up to 70 lbs. as giving all the economy to be expected under ordinary circumstances. For pressures of from 80 to 100 lbs., two stage compression in cylinders properly proportioned certainly results in a very material saving of power, in addition to the other advantages of compounding. For pressures above 100 lbs. stage compression is essential for the best economy.

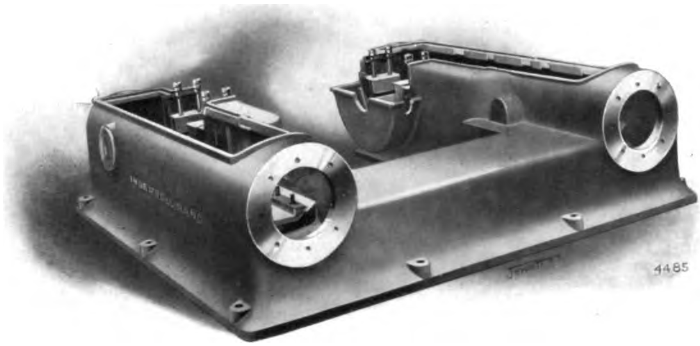
Intercooler

"Imperial XB" Compressors with compounded air ends have an intercooler designed to give the maximum efficiency. The location of this intercooler varies with the size of the compressor. In smaller sizes it is placed crosswise of the compressor beneath the air cylinders; on larger sizes the intercooler is crosswise of the compressor and above the air cylinders. Precautions have been taken in the



The Overhead Intercooler Used on the Larger Sizes of "Imperial XB-2" Compressors

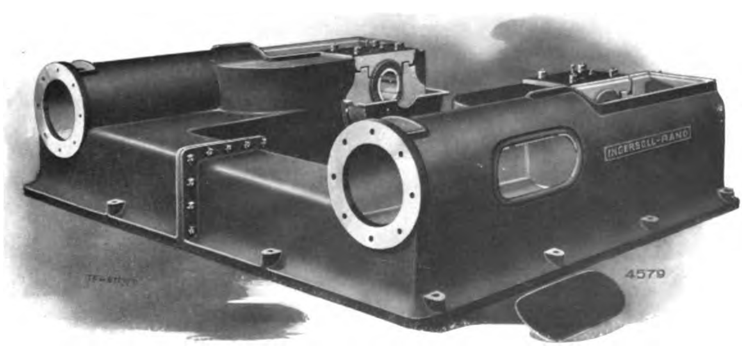
construction of the intercooler to avoid any leakage of air or water due to the expansion and contraction of the tubes under changes of temperature. The large cross-section of the air passages obviates any appreciable drop in pressure between the high and low pressure cylinders.



The Single-Piece Main Frame Used on the Smaller Sizes of "Imperial XB" Compressors

Mechanical Efficiency

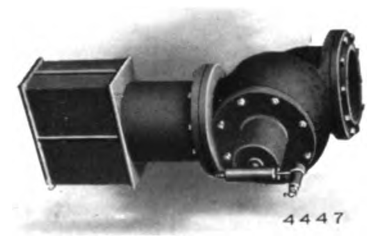
The mechanical design of "Imperial XB" Compressors throughout is such as to secure the highest efficiency in the transmission of power from the drivıng to the compressing elements. Superfluous details of questionable value are eliminated. Bearings are unusually large and bearing pressures moderate, resulting in a very low friction loss. The metal in all parts is carefully selected and so disposed as to give the maximum resistance to distortion under pressure.



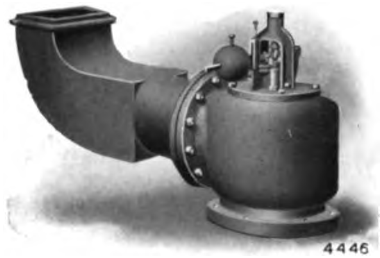
The Two-Piece Main Frame Used on the Larger "Imperial XB" Sizes

Regulation

The requirements of regulation under changing load at constant speed are adequately met in the "Imperial XB" by two types of governors or regulators. These are the Rand "Imperial Unloader" and the Ingersoll "Choking Controller," both operating to reduce the area of the air inlet passage when load falls below normal. They are automatic in operation and economical under load variation. The "Imperial Unloader" is furnished on "XB-1" single stage machines, one device regulating the intake of both duplex air cylinders. On "XB-2" two stage machines, either the "Imperial Unloader" or the "Choking Controller" can be used governing the air supply to the low pressure cylinder.



Imperial Unloader



Choking Controller

Materials and Workmanship

From the raw material to the finished product every stage of the manufacture of "Imperial XB" Compressors is under the eye of skilled experts. The composition of the metal of cast parts is a matter of long experience, resulting in qualities which best adapt them to the particular service for which they are intended. The degree of carbonization in the steels used is varied to meet different conditions. Steel parts requiring great toughness and resisting qualities are given an oil treating process which not only increases their elastic limit,but adds twenty-five to thirty per cent to their tensile strength.

Interchangeability

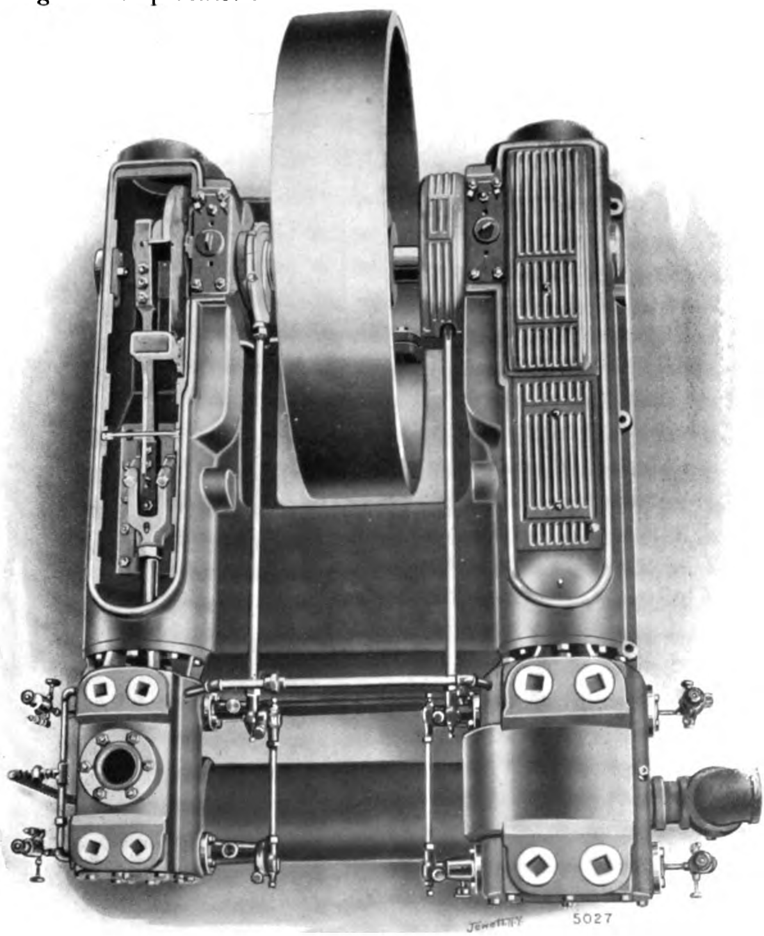
Every part is tested by a system of limit gages and must conform exactly with the most accurate standards before it is passed. Working parts of the machine are carried in stock at factory or branch and are supplied to customers under a guarantee of interchangeability.

Tests

Every "Imperial XB" machine is given an adequate test before shipment, and leaves the shop in proper adjustment and in perfect condition. Thereafter it is backed by the liberal guarantees of the Ingersoll-Rand Company.

Sizes, Capacities, and Construction Details

The standard sizes and capacities of "Imperial XB" machines are given in the tables following. Details of construction are described in the specifications, which will be furnished to those asking for a quotation.



Plan view of "Imperial XB-2" Compressor with Underneath Intercooler; Covers Removed from One-Half of the Machine to Show the Interior Arrangement.

"IMPERIAL XB-1" DUPLEX POWER DRIVEN AIR COMPRESSORS

AIR PRESSURE, 15 TO 100 POUNDS

Telegraph Name	Cylind's, Inches: Diameter Each Duplex Air Cylinder	Cylind's, Inches: Stroke	R. P. M.	Piston Displacement Cubic Feet per Minute	Air Pressure Designed For: Min.	Air Pressure Designed For: Max.	Brake Horse-Power Required at Belt Wheel of Compressor: Min.	Brake Horse-Power Required at Belt Wheel of Compressor: Max.	Standard Belt Wheel: Diameter, Inches	Standard Belt Wheel: Face, Inches	Over-all Dimensions Feet and Inches: Length	Over-all Dimensions Feet and Inches: Width
Refag .	6½	8	200	120	70	100	20	24	42	8½	6– 9	4–11
Refeh .	8	8	200	181	40	60	21	28	42	8½	6–11	4–11
Refij. .	10	8	200	288	20	30	20	28	42	8½	6–11	5– 1
Refok .	7½	10	190	191	70	100	31	38	54	10½	7–11	5– 4
Reful .	9	10	190	276	45	65	35	44	54	10½	8– 1	5– 4
Regah .	11	10	190	415	35	40	45	49	54	10½	8– 0	5– 5
Regik .	12	10	190	494	20	30	36	48	54	10½	8– 0	5– 5
Regol .	9	12	175	305	70	100	49	60	60	12½	9– 1	5–11
Regum	11	12	175	457	45	60	57	68	60	12½	9– 1	5–11
Rehaj .	13	12	175	641	35	40	68	76	60	12½	9– 5	6– 0
Rehek .	14	12	175	744	20	30	53	72	60	12½	9– 5	6– 0
Rehil .	10	14	165	412	75	100	68	80	72	16½	10– 6	7– 4
Rehom.	12	14	165	597	50	70	78	96	72	16½	10–11	7– 4
Rehun .	14	14	165	816	35	45	87	102	72	16½	10– 6	7– 4
Rejak .	16	14	165	1068	20	30	75	101	72	16½	10– 6	7– 5
Rejel .	12	16	150	620	70	100	97	119	84	20½	11–11	8– 2
Rejim .	14	16	150	846	45	65	100	129	84	20½	12– 0	8– 2
Rejon .	16	16	150	1108	35	40	116	127	84	20½	12– 0	8– 2
Rejup .	18	16	150	1408	20	30	98	133	84	20½	12– 0	8– 4
Rekal .	14	16	150	844	80	100	143	162	84	28½	12– 0	8– 2
Rekem	16	16	150	1104	55	75	152	184	84	28½	12– 0	8– 2
Rekin .	18	16	150	1403	45	50	170	183	84	28½	12– 0	8– 4
Rekop .	20	16	150	1734	35	40	181	199	84	28½	12– 3	8–10
Rekur .	22	16	150	2102	20	30	146	198	84	28½	12– 3	8–10
Relam .	14	20	150	1055	80	100	182	200	96	31½	14– 2	9– 2
Relen .	16	20	150	1383	55	70	184	232	96	31½	14– 3	9– 2
Relip .	18	20	150	1753	45	50	210	224	96	31½	14– 3	9– 4
Relor .	20	20	150	2168	35	40	224	246	96	31½	14– 5	9–10
Relus .	22	20	150	2624	20	30	179	244	96	31½	14– 5	9–10
Reman	16	20	150	1376	85	100	236	258	96	40½	14– 2	10– 0
Remep	18	20	150	1747	60	80	244	292	96	40½	14– 2	10– 0
Remir .	20	20	150	2161	45	50	258	293	96	40½	14– 4	10– 6
Remos .	22	20	150	2623	35	45	271	297	96	40½	14– 4	10– 6
Remut .	25	20	150	3384	20	30	232	314	96	40½	14– 8	10–10
Renap .	18	24	140	1954	85	100	334	363	120	48½	17– 0	12– 6
Rener .	20	24	140	2414	65	80	352	400	120	48½	17– 0	12– 6
Renis .	22	24	140	2931	50	60	364	416	120	48½	17– 0	12– 6
Renot .	24	24	140	3498	35	45	350	412	120	48½	17– 8	12– 8
Renuv .	26	24	140	4104	25	30	330	375	120	48½	17– 8	13– 4
Repar .	28	24	140	4763	15	25	260	386	120	48½	17– 8	13– 4

"IMPERIAL XB-2" TWO STAGE POWER DRIVEN AIR COMPRESSORS

For Air Pressures of 80 to 100 Pounds — **For Sea Level**

Telegraph Name	Dimensions of Air Cylinders, Inches: Diameter of Low Pressure	Dimensions of Air Cylinders, Inches: Diameter of High Pressure	Dimensions of Air Cylinders, Inches: Stroke	Revolutions per Minute	Capacity Cubic Feet of Free Air per Minute	Standard Belt Wheel: Diameter, Inches	Standard Belt Wheel: Face, Inches	Brake Horse-Power Required at Belt Wheel of Compressor, Air Pressure: 80 lbs.	Brake Horse-Power Required at Belt Wheel of Compressor, Air Pressure: 100 lbs.	Over-all Dimensions Ft. and In.: Length	Over-all Dimensions Ft. and In.: Width
Raxen	10	6½	8	200	144	42	8½	24	27	6–11	6– 0
Raxip	12	7½	10	190	247	54	10½	41	46	8– 0	6– 6
Raxot	14	9	12	175	372	60	12½	62	69	9– 3	7– 4
Raxus	16	10	14	165	534	72	16½	87	98	10– 6	8– 9
Rayan	18	11	16	150	704	84	20½	113	127	12– 0	10– 1
Rayep	22	13	16	150	1051	84	28½	170	190	12– 5	10– 6
Rayir	22	13	20	150	1312	96	31½	208	234	14– 7	12– 3
Rayos	25	15	20	150	1692	96	40½	268	300	14– 8	11– 9
Rayut	28	17	24	140	2381	120	48½	373	419	17– 8	13–10

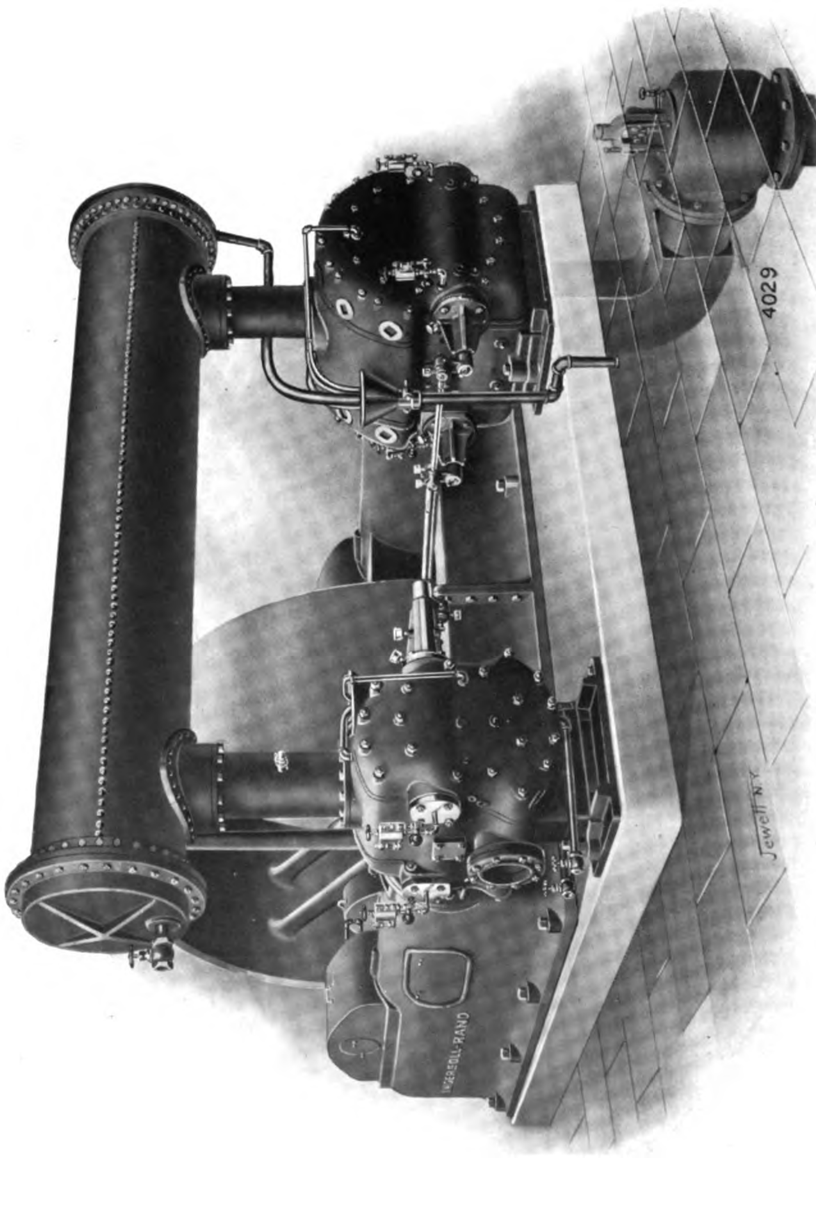
Compound Air Cylinders for 5,000 and 10,000 Feet Altitude. For Power Driven "Imperial XB-2" Compressors

For Air Pressures of 80 to 100 Pounds — **For 5,000 Feet Altitude**

Telegraph Name	Dimensions of Cylinders, Inches: Low Pressure Cylinder	Dimensions of Cylinders, Inches: High Pressure Cylinder	Dimensions of Cylinders, Inches: Stroke	Revolutions per Minute	Capacity Cubic Feet of Free Air per Minute	Standard Belt Wheel: Diameter, Inches	Standard Belt Wheel: Face, Inches	Brake Horse-Power Required at Belt Wheel of Compressor, Air Pressure: 80 lbs.	Brake Horse-Power Required at Belt Wheel of Compressor, Air Pressure: 100 lbs.	Over-all Dimensions Ft. and In.: Length	Over-all Dimensions Ft. and In.: Width
Razap	11	6½	8	200	174	42	8½	27	30	6–11	6– 0
Razer	13	7½	10	190	291	54	10½	44	49	8– 2	6– 8
Razis	15	9	12	175	427	60	12½	65	72	9– 5	7– 4
Razot	17	10	14	165	602	72	16½	90	100	10– 7	8– 9
Razuv	19	11	16	150	784	84	20½	115	128	12– 0	10– 1
Rebac	23	13	16	150	1149	84	28½	169	188	12– 5	10– 6
Rebed	23	13	20	150	1435	96	31½	208	230	14– 7	12– 3
Rebif	26	15	20	150	1833	96	40½	264	294	14– 8	11– 9
Rebuh	29	17	24	140	2554	120	48½	365	405	17– 8	13–10

For 10,000 Feet Altitude

Telegraph Name	Low Pressure Cylinder	High Pressure Cylinder	Stroke	Revolutions per Minute	Capacity Cubic Feet of Free Air per Minute	Diameter, Inches	Face, Inches	80 lbs.	100 lbs.	Length	Width
Recef	12	6½	8	200	207	42	8½	29	32	7– 1	6– 0
Recig	14	7½	10	190	338	54	10½	47	52	8– 4	6– 7
Recoh	16	9	12	175	487	60	12½	67	74	9– 5	7– 5
Recuj	18	10	14	165	677	72	16½	91	101	10– 7	8– 9
Redaf	20	11	16	150	868	84	20½	115	127	12– 1	10– 3
Redeg	24	13	16	150	1251	84	28½	166	184	12– 7	10– 6
Redih	24	13	20	150	1564	96	31½	204	226	14– 9	12– 3
Redoj	27	15	20	150	1978	96	40½	258	286	15– 2	11– 9
Reduk	30	17	24	140	2738	120	48½	354	392	18– 2	13–10

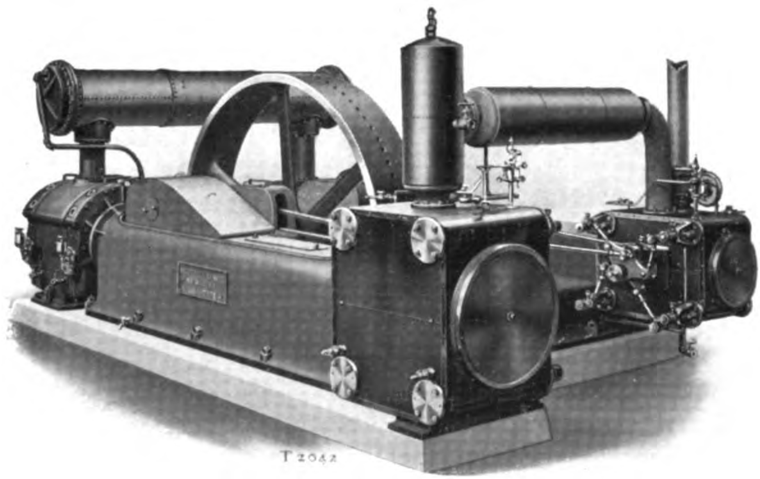


Large "Imperial XB-2" Two Stage Compressor with Overhead Intercooler, Two-Piece Frame and "Choking Controller," for an Idaho Mine

"IMPERIAL-CORLISS XC"
DUPLEX STEAM DRIVEN
COMPRESSORS

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 3013 February, 1910



Standard "Imperial-Corliss XC-3" Air Compressor, with Compound Steam and Air Cylinders

IN the "Imperial-Corliss XC" Compressor are combined the distinctive advantages of the "Imperial" type with the steam economy of the Corliss steam valve gear. It is a high-duty compressor in the true sense, but moderate in first cost, low in maintenance charges, and highly economical of fuel and steam. The air end of the "Imperial-Corliss" is practically identical with the air end of the "Imperial X" Meyer valve steam driven, and the "Imperial XB" power driven. These two latter types are described in separate pamphlets. The "Imperial-Corliss" is especially adapted for permanent plants of high economy, but a notable instance of its use in contract work is illustrated on page 11, the largest high pressure air plant ever installed for contract service under one roof.

A Unit Construction

The "Imperial XC" compressor represents a unique design among Corliss compressor types. While belonging distinctly in the duplex class, the heavy and substantial main frame carrying all other parts makes the machine a solid and self-contained unit, as much so as a straight line machine. The air and steam cylinders, being bolted to this frame, are in no way dependent upon the foundation for correct alignment. The bearings are an integral part of the frame. The fly wheel is hung centrally both as to length and breadth of the machine, the weight of the machine being thus evenly distributed over the foundation.

Accessibility

When the compressor is in operation the driving wheel and valve gear are practically the only moving parts visible. Cranks, connecting rods, crossheads, eccentrics are all enclosed in the casing of the base, yet every part is readily accessible by removing covers from the casing. It may be well to emphasize the fact that the "Imperial XC" is accessible *while running*. The system of lubrication is a flood system, so that the cover plates can be removed without any danger of oil being thrown out. The "Imperial" in point of accessibility has all the advantages of the open type of machine, with the attendant advantages of enclosed automatic lubrication. The bore of any cylinder can be exposed for inspection by simply removing the outside head, without disturbing any other part of the machine.

Duplex Advantages

The many recognized advantages of the duplex construction in steam driven air compressors are fully embodied in "Imperial" machines. A few of these may be mentioned here: a balanced construction, with quartered cranks effecting an equalization of efforts; the absence of any "dead centre," giving close regulation over a wide range of load variation; the reduction of structural stresses by this balanced construction; the ease with which the steam or air cylinders may be compounded, with all the attendant economies and without any increase in the number of working parts.

Ease of Installation

The solid box bed of the "Imperial" obviates the only objection ever rightfully urged against the duplex type. It makes the machine practically independent of its foundation, and this, together with the compactness of the design, permits a simple, small, and therefore less

costly foundation. The installation of one of these machines consists simply in placing it on the foundation, leveling up, tightening the anchor bolts, grouting the joints, and connecting up the piping. There is no "lining up" in the ordinary sense.

Large Air Capacity

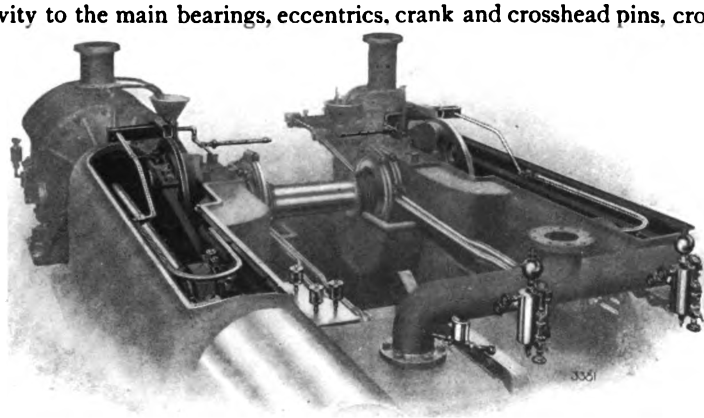
The "Imperial XC" has a greater air capacity per unit floor space than most other steam driven compressor types. This is due directly to the higher speeds possible in this design, and secondarily to the exclusive features of the design itself. Examination of the tables on pages 14 and 15 show a rotative speed which has been demonstrated in many instances — in many cases after years of heavy duty — to be thoroughly practical and safe.

Some Exclusive Features of Design

This unusual fact is to be credited to several exclusive features of design, among which the following may be emphasized: the massive, well-braced structure; the unusually generous bearing surfaces; the improved Corliss steam valve gear; the exceptionally thorough lubrication, automatic and ample at all speeds; the mechanically actuated air intake valves with large, direct passages; the light-running, almost noiseless discharge valves; and the care bestowed upon every detail of construction.

The Lubricating System

The system of lubrication is unique and unsurpassed. The crank disks, dipping into an oil chamber in the main frame, deliver oil by means of a wiper pan to pockets or reservoirs from which it flows by gravity to the main bearings, eccentrics, crank and crosshead pins, cross-

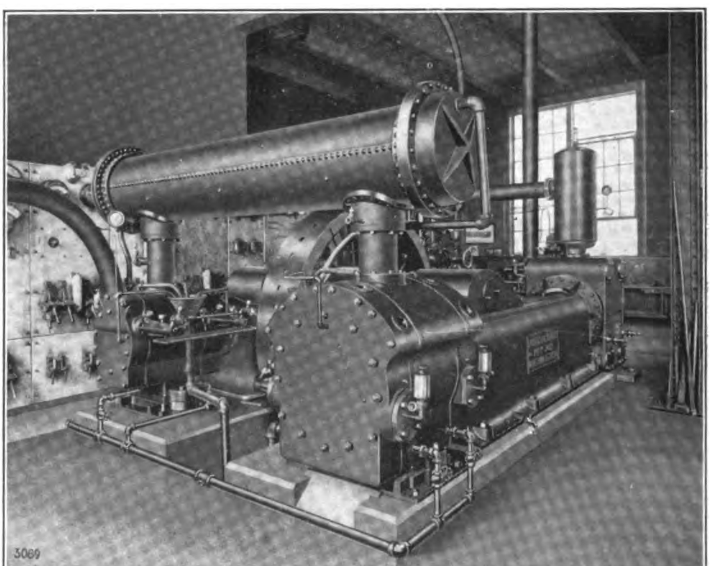


The Automatic Flood Lubrication System of "Imperial" Compressors

head guides and piston rods, which are literally flooded with oil at all speeds. It is impossible for any bearing to run dry so long as an adequate supply of oil is maintained in the crank basin. The overflow from the bearings is returned to the crank chamber and used over again. The "Imperial" is one of the most cleanly compressors on the market. The cylinders have sight-feed oilers and the bearings of the valve gear are fitted with oilers and grease cups.

Economy of Oil

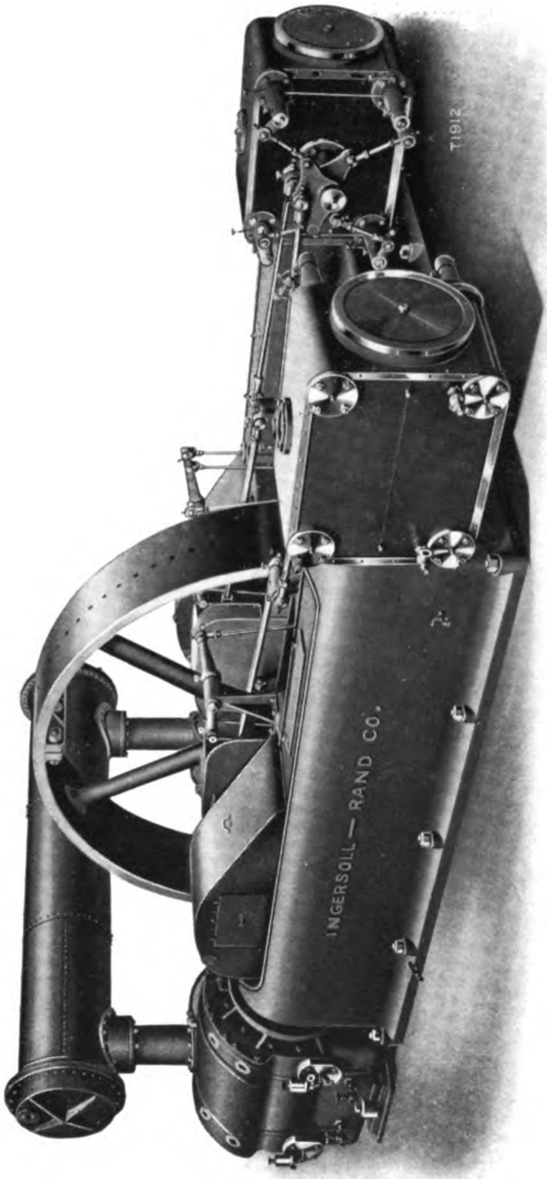
This system of lubrication, characteristic of all "Imperial" types, results in a marked economy of oil. A typical instance is that of a 12-inch stroke, steam driven "Imperial" which in running eight months at an average of eighteen hours per day, used only ten gallons of oil, this including both machine and cylinder oil. During this time no evidence of hot bearings developed; and of these ten gallons of oil six were recovered, filtered, and used for other purposes. This example illustrates not only the oil economy of the machine, but also the superior workmanship throughout every part.



"Imperial-Corliss XC-3" Compressor in the Plant of Wellman-Seaver-Morgan Co., Cleveland, Ohio

An Adaptable Type

The sensitive and quick-acting regulating devices and the novel system of lubrication make this compressor as automatic in action as



Standard "Imperial-Corliss XC-2" Compressor, with Simple Duplex Steam Cylinders and Cross-Compound Two Stage Air Cylinders with Overhead Intercooler

a machine of this type can be. The design admits of almost every possible combination of driving and compressing elements. These features, combined with the large air capacity, have made the "Imperial" type one of the most popular machines for all classes of service, but particularly for conditions demanding great capacity and perfect reliability combined with minimum dimensions and automatic operation.

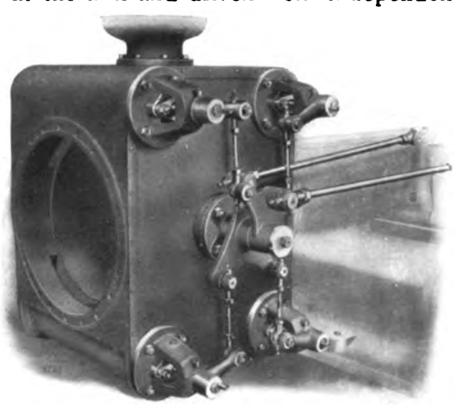
Standard Classifications

Tabulated and detailed specifications of the "Imperial-Corliss" line are given on pages 14 and 15, but at this point the following classifications are to be noted, giving the standard symbol which designates each modification of the basic type.

"Imperial-Corliss XC-1" — Duplex Steam and Duplex Air Cylinders
"Imperial-Corliss XC-2" — Duplex Steam and Compound Air Cylinders
"Imperial-Corliss XC-3" — Compound Steam and Compound Air Cylinders
"Imperial-Corliss XC-4" — Compound Steam and Duplex Air Cylinders

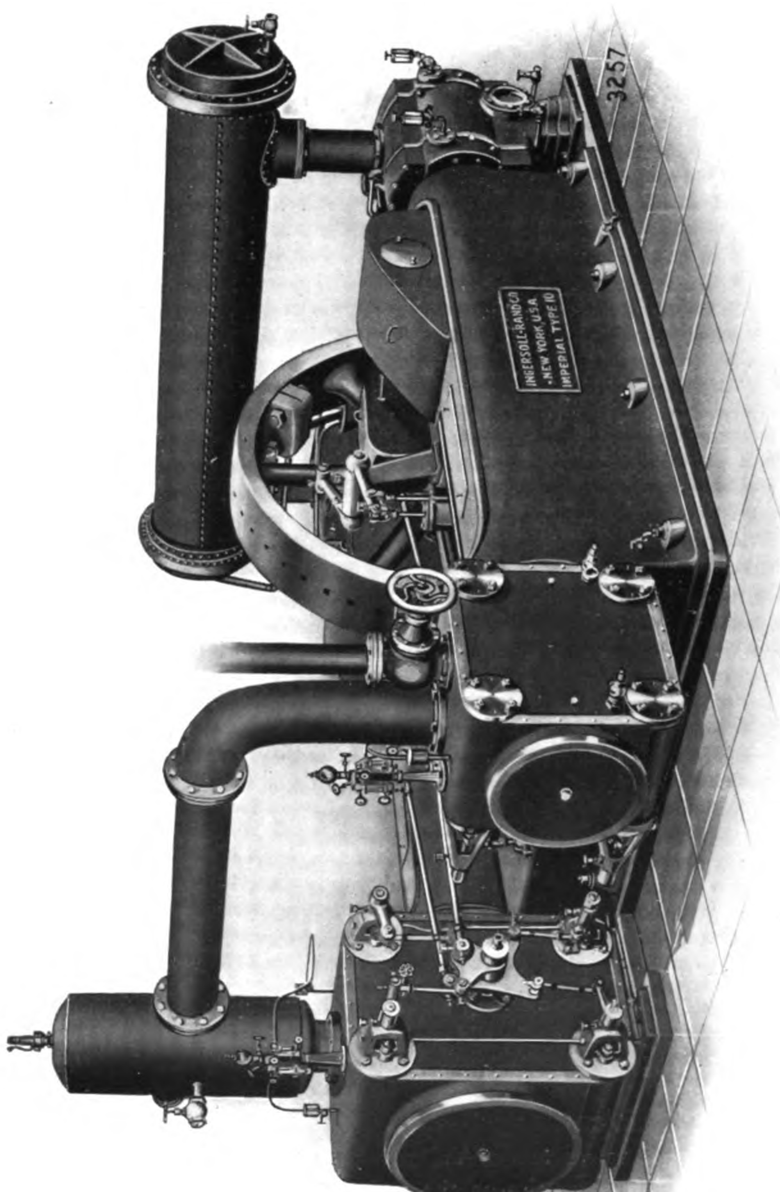
The Steam End

Both steam and exhaust valves are of the true Corliss type, operated by a link, the steam and exhaust valves being independently connected at the link and driven from independent wrist-plates. This conforms with the latest and best Corliss engine practice. The valve movement has not the automatic release of the regular Corliss motion, thus dispensing with dash pots and cams, and permitting a much higher rotative speed. While the exhaust valves have fixed release and compression, the steam valves on the high pressure cylinder are driven by connections with a sliding block in the link.



"Imperial-Corliss" Steam Cylinder and Steam Valve Gear

Cut-off and therefore the speed are varied by changing the position of



"Imperial-Corliss XC-3"; Cross-Compound Steam Cylinders with Steam Receiver; Two Stage Air Cylinders with Overhead Intercooler

this block, this function being performed by the governor. Among the advantages of this valve gear are the following: It permits higher piston speeds than the regular release movement; it has no delicate parts and no complication; it practically attains Corliss economy without release mechanism; it maintains this economy at all loads and speeds; it is designed for absolute reliability under all conditions.

Compounded Steam Cylinders

The advantage of compounded steam cylinders lies in the higher expansion thus secured. The degree of expansion is determined by the initial and terminal pressures. The initial pressure is, of course, fixed by the boiler pressure; but the terminal pressure depends upon whether or not a condenser is used, and upon the degree of vacuum obtained. With low steam pressures, non-condensing, compound steam cylinders are not advisable.

Steam Pressures for Compounding

"Imperial-Corliss" Compressors may be adjusted to a cut-off which is best for the particular pressure carried. The steam expansion is practically constant regardless of the speed, and compound economy is always practically maintained whatever the load. Experience has shown that where these machines can be run condensing it is well worth while to compound the steam cylinders on steam pressures as low as 80 lbs. gage. Running non-condensing, however, 90 lbs. gage is about the lowest initial pressure with which compounded steam cylinders can be profitably used. Below these pressures duplex steam cylinders probably give as good economy as can be expected.

Air Cylinders

The air cylinders of all "Imperial" Compressors are designed for maximum compression efficiency. Barrels and heads are water jacketed, the latter being hooded for the admission of cool, clean air. Both inlet and discharge valves are in the cylinder heads. The air cylinders are supported on a strong foot-piece resting upon a sole-plate on the foundation, and may be slid away on this sole-plate when it is necessary to detach the cylinder from the frame.

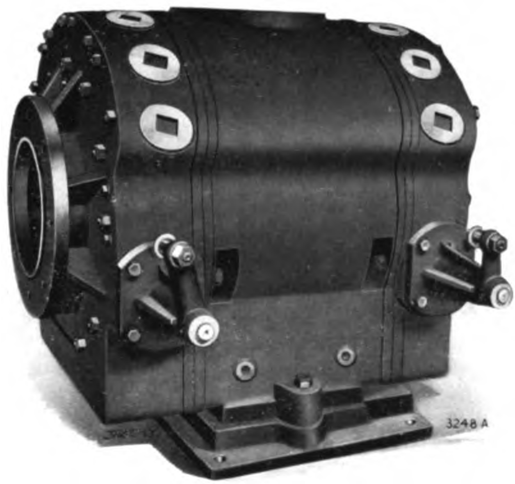
Air Intake Valves

The air intake valves are of the well-known "Imperial-Corliss" type, operated from eccentrics on the main shaft. These valves are of unusually large diameter and provide the shortest and most direct

passage for the entering air, with the minimum of clearance. The working pressure is evenly distributed over the entire valve surface, which is almost exactly a half circle; and this pressure being always central, there is no tendency to wear either the edges of the valve or the surfaces with which they come in contact. The valve adjustments are so fixed that they cannot be disarranged by an incompetent attendant.

Air Discharge Valves

Air discharge valves are of the "Imperial Direct Lift" pattern. Their lift is ample and the port passages are short and free. Springs are of large diameter and close pitch, with sufficient tension for their work, yet imposing no undue load upon the machine. The spring absorbs the shock at the end of the lift, reduces the noise of operation, and gives a longer life to the mechanism. In fact these discharge valves are almost noiseless in operation.



A Typical "Imperial" Air Cylinder, with "Imperial-Corliss" Inlet and "Imperial Direct Lift" Discharge Valves

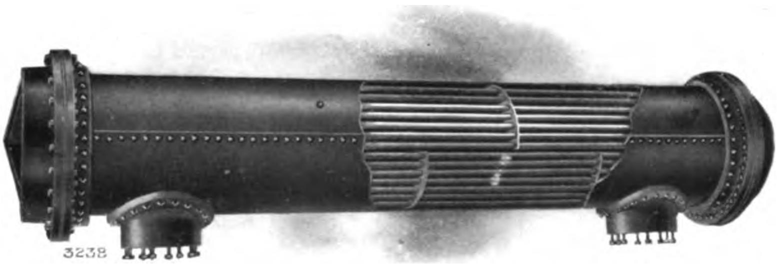
Compound Air Cylinders

The economical advantages of stage or compound compression are so generally understood that they need not be discussed here. The best practice adopts single stage compression for pressures up to 70 lbs. as giving all the economy to be expected under ordinary circumstances. For pressures of from 80 to 100 lbs., two stage compression in cylinders properly proportioned certainly results in a very material saving of power, in addition to the other advantages of compounding. For pressures above 100 lbs., stage compression is essential for the best economy.

Intercooler

"Imperial-Corliss" Compressors with compound air ends have an intercooler designed to give the maximum efficiency, set crosswise of

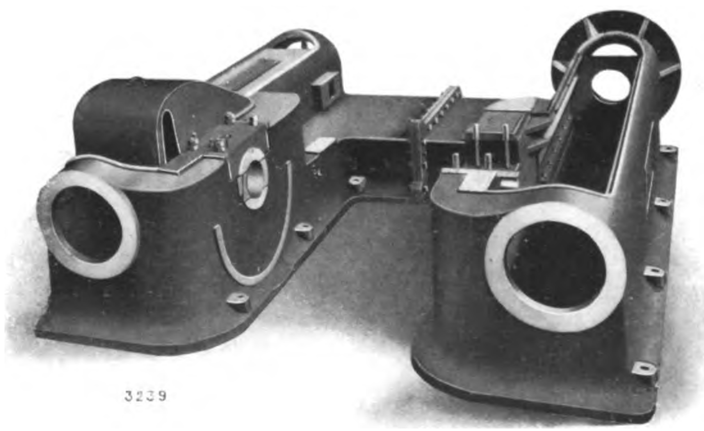
the compressor and above the air cylinders. Precautions have been taken in the construction of the intercooler to avoid any leakage of air or of water due to the expansion and contraction of the tubes under extremes of temperature. The large cross-section of the air passages produces no appreciable drop in pressure between the high and low pressure cylinders. The entire nest of tubes can be removed from the shell for inspection or cleaning.



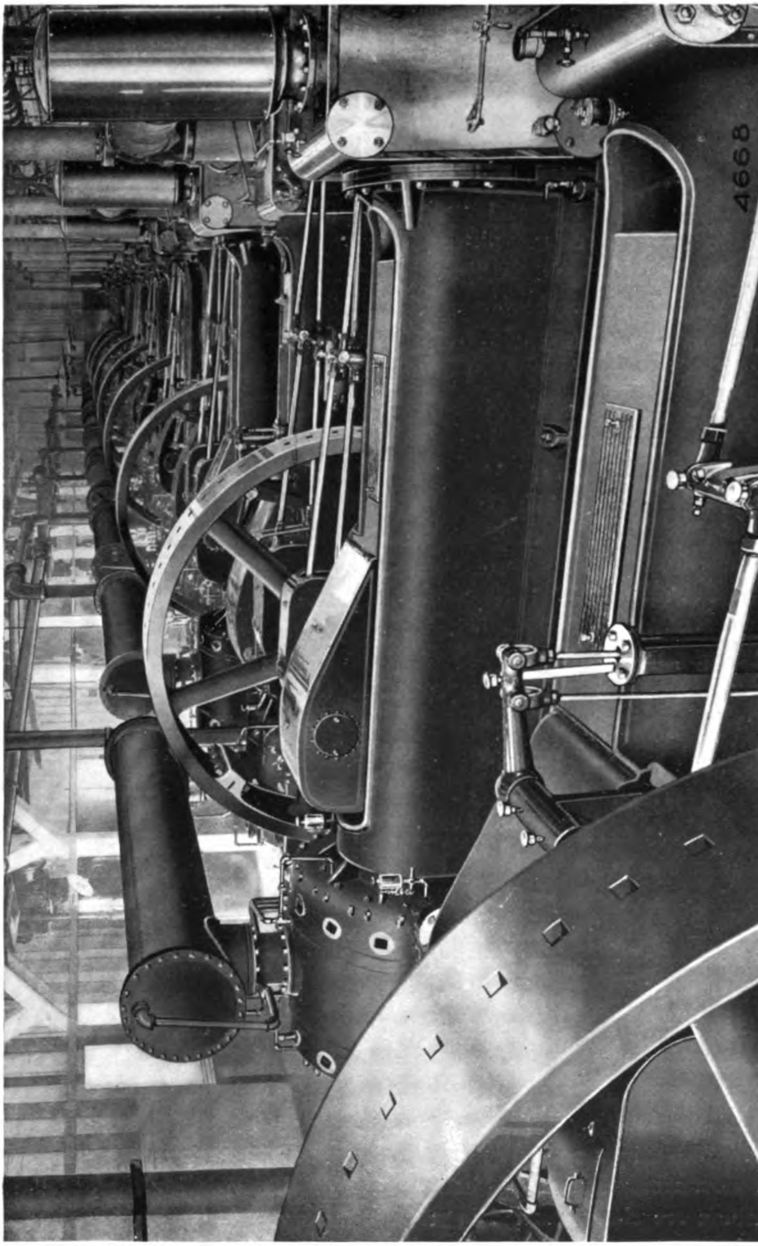
The Overhead Intercooler used on " Imperial-Corliss XC-2 " and " XC-3 " Compressors

Mechanical Efficiency

The mechanical design of " Imperial-Corliss " Compressors throughout is such as to secure the highest efficiency in the transmission of power from the driving to the compressing elements. Superfluous details of questionable value are eliminated. Bearings are unusually large and bearing pressures moderate, resulting in a very low friction



The Main Frame of the " Imperial-Corliss " Compressor, showing the Two-Piece Construction



The Largest High Pressure Contract Plant ever installed under One Roof: Ten "Imperial-Corliss XC-3" Compressors on the Rondout Siphon of the Catskill Aqueduct; T. A. Gillespie Co., Contractors: Total Free Air Capacity 24,000 cu. ft. per min. to 110 lbs. Pressure

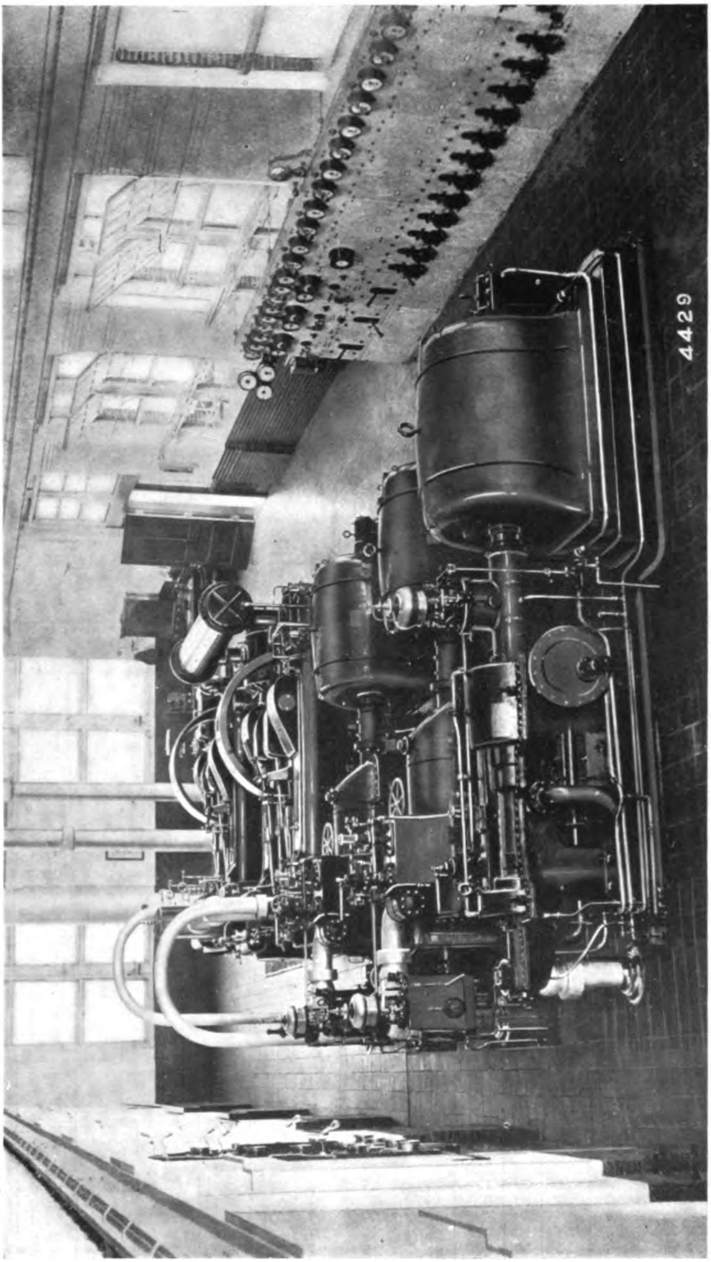
loss. The metal in all parts is carefully selected and so disposed as to give the maximum resistance to distortion under pressure.

Regulation

Each "Imperial-Corliss" compressor is furnished with an automatic fluid governor which regulates the speed by changing the cut-off, this being accomplished by moving the block in the valve link. This block is connected by levers and arms to a piston in an oil cylinder. The pressure of the oil on this piston is opposed by weights on a lever. An oil pump, driven from the main shaft, circulates the oil through a passage provided with an adjustable overflow, into the governor cylinder and thence back to the pump. In this overflow passage is a piston-controlled valve which acts under receiver pressure to alter the passage to the governor piston. When receiver pressure rises above normal, this valve throttles the overflow, increasing the oil pressure on the governor piston, shortening the cut-off and reducing the speed until normal pressure is recovered, when the governor weights restore normal conditions. If, under light load, the compressor momentarily speeds above normal, the overflow passage cannot accommodate the increasing volume of oil; the oil pressure on the piston increases; the link block is lowered and the speed is reduced to normal. The device is automatic, adjustable for any pressure and under perfect control. Steam consumption is economically proportioned to the demand for air. A safety stop is provided which automatically brings the machine to a stand-still, should the governor chain break or excessive speed be otherwise reached.

Materials and Workmanship

From the raw material to the finished product every stage of the manufacture of "Imperial-Corliss" Compressors is under the eye of skilled experts. The composition of the metal of cast parts is a matter of long experience, resulting in qualities which best adapt them to the particular service for which they are intended. The degree of carbonization in the steels used is varied to meet different conditions. Steel parts requiring great toughness and resisting qualities are given an oil treating process which not only increases their elastic limit, but adds twenty-five to thirty percent to their tensile strength. Every wearing part is tested by a system of limit gages and must conform exactly with the most accurate standards before it is passed. Working parts of the machine are always carried in stock at factory or branch and are supplied to customers under a guarantee of absolute interchangeability.



Two "Imperial-Corliss" Air Compressors in the Eaton, Cole & Burnham Plant of the Crane Co., Bridgeport, Conn.
Note the Compactness of these Units as compared with the Turbo-Generators Alongside

Tests

Every "Imperial-Corliss" machine is given a long test run before shipment, and leaves the shop in proper adjustment and in perfect condition. Thereafter it is backed by the liberal guarantees of the Ingersoll-Rand Company.

Sizes, Capacities, and Construction Details

The standard sizes and capacities of "Imperial-Corliss" machines are given in the tables immediately following. Every important detail of construction is fully described and discussed in the specifications covering these machines, which will be furnished to those asking for a quotation on a compressor to meet certain stated conditions.

"IMPERIAL-CORLISS" "XC-1" DUPLEX STEAM DRIVEN AIR COMPRESSORS

SIMPLE DUPLEX STEAM AND DUPLEX SINGLE STAGE AIR CYLINDERS

Steam Pressure, 80-120 lbs.; Air Pressure, 15-100 lbs.

Telegraph Name	Cylinders Inches: Diameters: Duplex Steam	Duplex Air	Stroke	R. P. M.	Piston Displacement Cubic Feet per Minute	Air Pressure Designed for: Min.	Max.	I. H. P. in Steam Cylinders: Min.	Max.	Overall Dimensions Feet and Inches: Length	Width	Height Above Floor
Ratom	14	14	20	150	1055	85	100	179	196	16- 5	8- 5	7- 2
Ratun	14	16	20	150	1383	55	80	182	229	16- 5	8- 5	7- 2
Rauhr	14	18	20	150	1753	45	50	205	220	15-11	8- 7	7- 2
Raujs	14	20	20	150	2168	35	40	219	240	16- 2	9- 1	7- 2
Raukt	14	22	20	150	2624	20	30	177	240	16- 2	9- 1	7- 2
Raunx	16	16	20	150	1376	85	100	230	253	17- 4	10- 0	7-11
Raupy	16	18	20	150	1747	60	80	240	286	17- 2	10- 0	7-11
Raurz	16	20	20	150	2161	45	55	250	284	16-11	10- 6	7-11
Rausb	16	22	20	150	2623	35	40	262	288	16-11	10- 6	7-11
Rautc	16	25	20	150	3384	20	30	226	306	17- 6	10-10	7-11
Rauvd	18	18	24	140	1954	85	100	327	359	19- 6	11- 6	8-10
Rauxg	18	20	24	140	2414	65	80	349	396	19- 6	11- 6	8-10
Ravak	18	22	24	140	2931	50	60	364	406	19- 6	11- 6	8-10
Ravel	18	24	24	140	3498	35	45	350	414	19- 6	11- 8	8-10
Ravim	18	26	24	140	4104	25	30	327	371	19- 7	12- 4	8-10
Ravon	18	28	24	140	4763	15	25	262	387	19- 7	12- 4	8-10
Ravup	20	20	30	120	2583	85	100	424	465	23- 0	13- 8	9- 6
Rawal	20	22	30	120	3132	70	80	462	504	23- 0	13- 8	9- 6
Rawem	20	24	30	120	3726	55	65	484	538	23- 0	13- 8	9- 6
Rawin	20	26	30	120	4390	45	50	502	539	23- 0	14- 0	9- 6
Rawop	20	28	30	120	5097	35	40	504	553	23- 0	14- 0	9- 6
Rawur	20	30	30	120	5856	25	30	462	524	23- 0	14- 0	9- 6
Raxam	20	32	30	120	6667	15	25	363	536	23- 0	14- 0	9- 6

"IMPERIAL-CORLISS" "XC-2" DUPLEX STEAM DRIVEN AIR COMPRESSORS

SIMPLE DUPLEX STEAM CYLINDERS; CROSS COMPOUND TWO STAGE AIR CYLINDERS

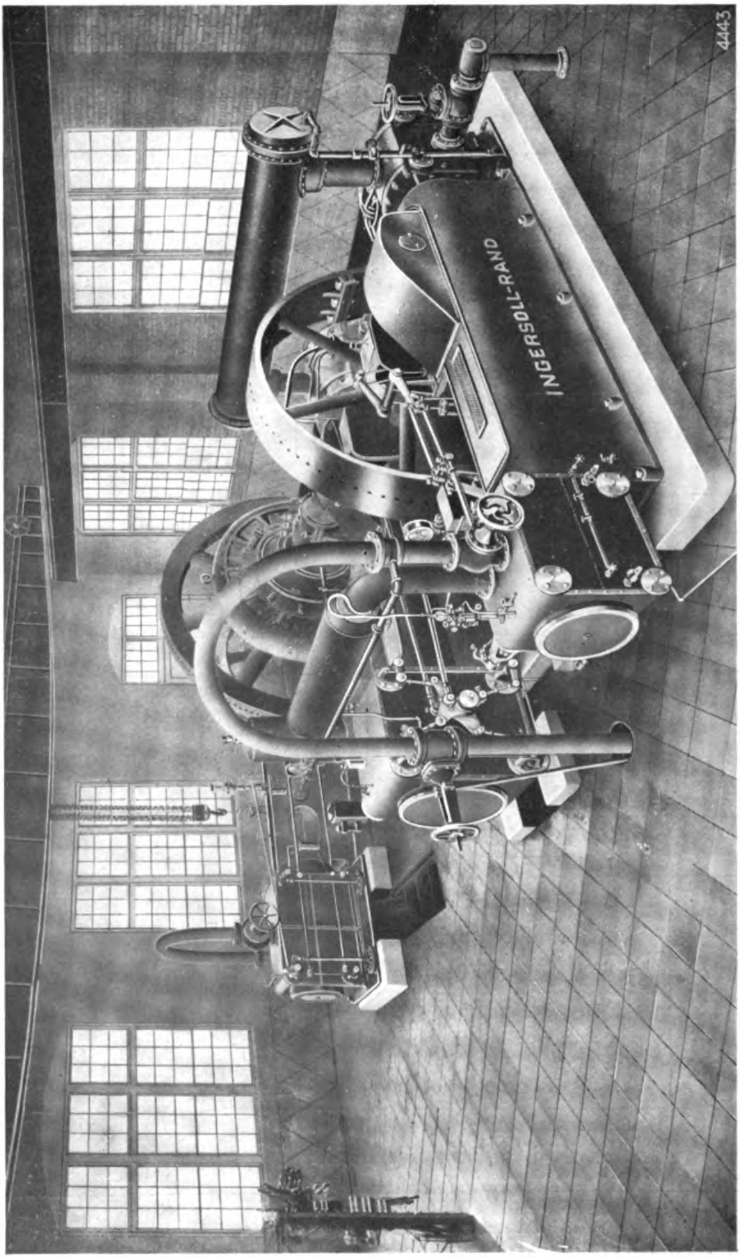
For Sea Level and Altitudes; Steam Pressure 80-120 lbs.; Air Pressure 80-100 lbs.

Telegraph Name	Cylinders, Inches				R. P. M.	Piston Displacement Cu. Ft. per Minute	I. H. P. in Steam Cylinders at Air Pressure Given		Overall Dimensions Feet and Inches		
	Diameters			Stroke							
	Duplex Steam	Low Pressure Air Cylinder	High Pressure Air Cylinder				80 lbs.	100 lbs.	Length	Width	Height Above Floor
Sea Level											
Raisy	14	22	13	20	150	1312	200	224	16-2	9-10	7- 2
Raitz	16	25	15	20	150	1692	254	286	17-6	11- 6	7-11
Raixd	18	28	17	24	140	2381	358	403	19-7	12- 6	8-10
Rajay	20	32	20	30	120	3333	495	558	23-0	14- 0	9- 6
5000 Feet Alt.											
Rajez	14	23	13	20	150	1435	199	222	16-2	9-10	7- 2
Rajib	16	26	15	20	150	1833	252	280	17-6	11- 6	7-11
Rajoc	18	29	17	24	140	2554	350	390	19-7	12- 6	8-10
Rajud	20	33	20	30	120	3546	481	535	23-0	14- 0	9- 6
10,000 Feet Alt.											
Rakaz	14	24	13	20	150	1564	196	217	16-4	9-10	7- 2
Rakeb	16	27	15	20	150	1978	246	272	18-0	11- 6	8- 4
Rakic	18	30	17	24	140	2738	340	376	20-1	12- 6	9- 4
Rakod	20	34	20	30	120	3765	463	511	23-2	14- 0	9- 8

COMPOUND AND LOW PRESSURE DUPLEX STEAM CYLINDERS FOR "IMPERIAL-CORLISS" "XC" COMPRESSORS

Standard Duplex Cylinders	Equivalent Compound Steam Cylinders						Equivalent Low Pressure Duplex Steam Cylinders for 60-80 lbs. Steam Pressure	
	Condensing 90-120 lbs. Steam Pressure Non-Condensing 100-125 lbs. Steam Pressure			Condensing 125-150 lbs. Steam Pressure Non-Condensing 130-150 lbs. Steam Pressure				
	* Telegraph Name	Diam. H. P. Cylinder Inches	Diam. L. P. Cylinder Inches	* Telegraph Name	Diam. H. P. Cylinder Inches	Diam. L. P. Cylinder Inches	* Telegraph Name	Diameter Inches
14 × 20	Sfibb	16	24	Sfogg	14	24	Sfumm	16
16 × 20	Sfigm	18	28	Sform	16	28	Sgamb	18
18 × 24	Sfilz	20	30	Sfrac	18	30	Sgemm	20
20 × 30	Sflem	22	34	Sfulg	20	34	Sghil	22

* These code words are to be suffixed to code words for IMPERIAL-CORLISS "XC-1" and "XC-2" Compressors to specify compressors with compound steam cylinders or with low pressure duplex cylinders, as the case may be.



"Imperial-Corliss XC-3" Compressor in the Power House of the Pittsburg-Buffalo Co., Marianna, Pa.

AIR AND GAS COMPRESSORS

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

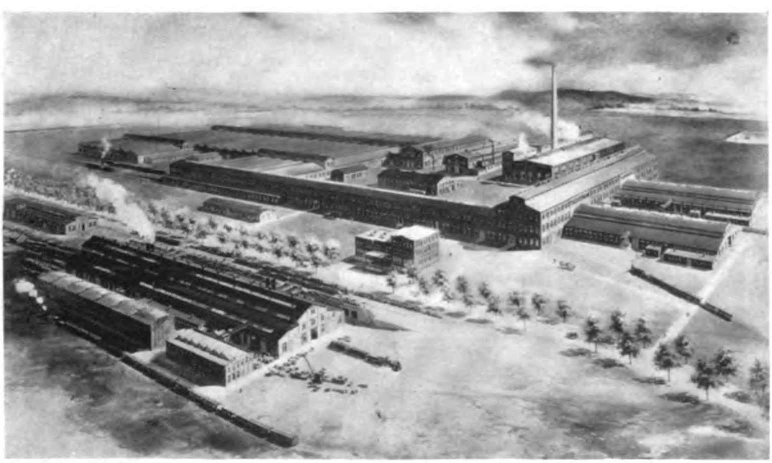
Form No. 3001 April, 1909

THE cost of compressed air involves three factors: first, the interest and depreciation on the plant investment; second, the operating cost; third, the maintenance or up-keep cost. All three of these depend upon the design and construction of the air compressor. A cheap machine may lower the first element of cost, but it will increase the other two elements. Good business, therefore, recommends the installation of a first-class machine at a fair cost, which will thereafter demand the minimum charge for operation and maintenance.

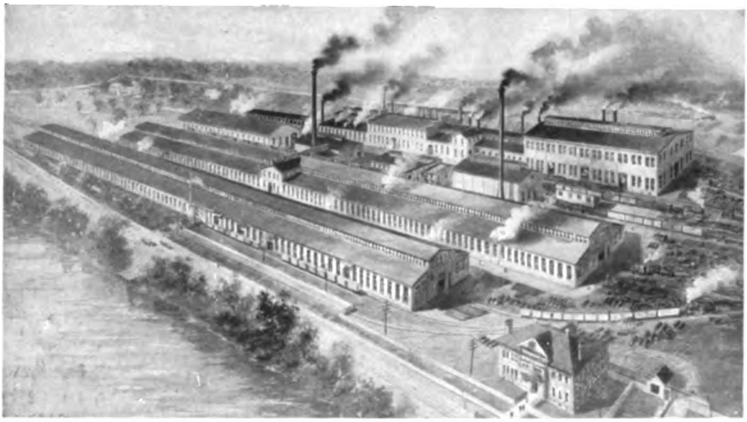
A Historical Sketch

For thirty-eight years (1909) the Ingersoll-Rand Company, or its constituent concerns, has directed its efforts toward the problem of compressor economy. The present Company is a union of the Ingersoll-Sergeant Drill Company and the Rand Drill Company.

The former concern dates back to 1871 and includes the Sergeant and Cullingworth Company and the Ingersoll Rock Drill Company.



Plant of the Ingersoll-Rand Co., at Phillipsburg, N. J.



Plant of the Ingersoll-Rand Co., at Easton, Pa.

The Rand Drill Company was started in 1871 as the Rand and Waring Drill and Compressor Company, later changed to the Rand Drill Company, incorporated in 1879.

Manufacturing Facilities and Output

Starting with the original small shops of the old Rand and Ingersoll Companies, in New York City, the growth of the business has necessitated the present large shops of the Ingersoll-Rand Company, located at Painted Post, New York, at Easton, Pa., at Phillipsburg, New Jersey, and at Athens, Pa. These works give employment to about 3500 men and, in combination,

Plant of Ingersoll-Rand Co., at Painted Post, N. Y.

they represent the largest, most complete and most highly organized shops for the building of air power machinery in the world.

The Phillipsburg Shops alone are the largest of the kind in the world; and the Company's total output to date (1909) is approximately as follows:

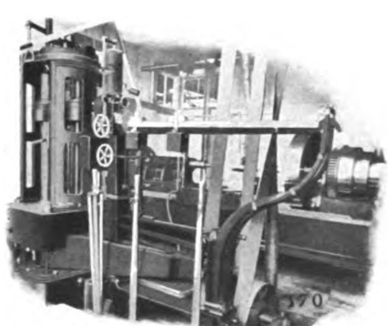
Air and Gas Compressors	850,000 H. P.
Rock Drills	100,000
Coal Cutters	6,000
Stone Channelers	600

Designs

The history of the Company, dating back to the beginning of pneumatic practise, is the history of the development of compressed air as a power; and the Company's engineers have originated the compressor types which find general acceptance to-day. More than a generation of specialized experience, therefore, is embodied in Ingersoll-Rand Compressors as at present built, commanding the confidence of the buying public in these machines as representing the most sound practise and the most advanced ideas.

Materials

The raw materials from which Ingersoll-Rand Compressors are built are the best that the market affords. Many of them are specially made to meet the Company's specifications. Composition metals are made from formulas covering a vast experience and observation. Cast iron is of a particular grade to meet the demand for a close, uniform, homogeneous structure, fine wearing qualities and the maximum strength. The steels used contain varying percentages of carbon for various purposes, the degree of carbonization representing the best judgment of experts for the particular service in question. Alloy steels are also used where the circumstances indicate that they are best for the purpose. All materials are rigidly tested before acceptance and must conform with the strict letter and spirit of the specifications.



A Testing Machine in the Materials Testing Department

Oil Treatment of Steel

An oil-treating process is used for all steel parts requiring unusual staying power; this process, very similar to that used by the United

The Oil Treating Department, Showing Oil Tanks and Annealing Furnaces

States Government on ordnance forgings, being the result of years of experiment. The steel, after rough machining, is heated to a high temperature and plunged in an oil bath where it remains until cool. The exact temperature used is determined by the results sought. From the oil bath the parts go to the annealing ovens, where all unbalanced stresses of cooling, straightening or forging are relieved. One result of this treatment is an increase of 25 to 30 per cent. in the tensile strength of the steel, meaning an equivalent addition to its "life" of usefulness. Other results are an increase in the elastic limit, in the ductility, and in the toughness of the steel.

Manufacturing Methods

Dimensional uniformity is one of the fundamental requisites of parts of Ingersoll-Rand Compressors. A uniform quality and

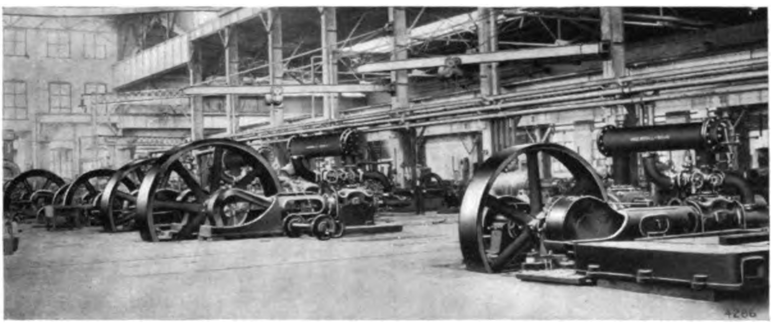
A Typical Group of Compressors in the Easton Shops, Showing the System of Building in Quantities

character of work is also sought. To this end the most advanced types of machine tools are used in the shops, automatic in operation so far as may be. Special tools have been built at great cost

for the manufacture of special parts in quantity. Expert supervision is over every detail of production. Skilled workmen only are employed, working under a system whereby it is to the interest of each to improve his product and better the character of his work. Machines are rarely built singly, but are put through the shops in lots of six, ten or twenty, as the case may be.

Interchangeability

Each part of an Ingersoll-Rand Compressor is separately inspected and measured by "limit gages" before acceptance for stock. All wearing parts, subject to replacement, must conform with the most exacting standards as to dimensional correctness This system of limit gage test enables the Company to maintain interchangeability of wearing parts, so that when repair parts are ordered, it will be with the assurance that they will fit in place correctly.



The Erecting Floor and Test Pits in the Phillipsburg Shops, with large Compressors being Erected and under Test and Inspection

Tests and Inspection

Aside from this test of individual parts, each machine during its assembling is inspected at every stage. The completed compressor then goes to the testing pit, where it is given a long test run at normal rated conditions, followed by another test at overload and higher speed. Indicator cards are repeatedly taken from all but the smallest stock machines, and these cards are made a part of the shop record of that machine. All adjustments are made on all machines for the best operating results. There can be no uncertainty as to the performance of an Ingersoll-Rand Compressor. It makes its record before it is shipped and when it leaves the shops it is known to be *right*. It goes out to work backed by the Company's prestige and guarantees.

Compressor Types

In pages following, the standard types of Ingersoll-Rand Compressors are illustrated and briefly described. It will be

noted that the line includes machines for low, moderate, high and very high pressure; steam and power driven, straight line and duplex, vertical and horizontal types; single, two, three and four stage compression; capacities from the very smallest to the largest standard listed size. Every possible demand can thus be met by some machine in this line; and from the "Baby" to the largest Corliss compressor, only one grade and quality is offered—the very best. The remarks in this pamphlet are applicable to every type and size built by the Company. Separate pamphlets, as listed in the sections following, give more complete descriptions of each type; and the specifications go into minute details of construction.

Air Valve Movements

The air valves used on various Ingersoll-Rand Compressor types are among the most prominent distinguishing features of these machines. Nothing will lower the economy of a compressor more quickly than defects or shortcomings in its air valves. The Company has therefore made a most careful study of these parts during its thirty-eight years of compressor building; and out of the multitude of different valve types invented, developed and tested, the following remain as representing all that is best in valve design and construction.

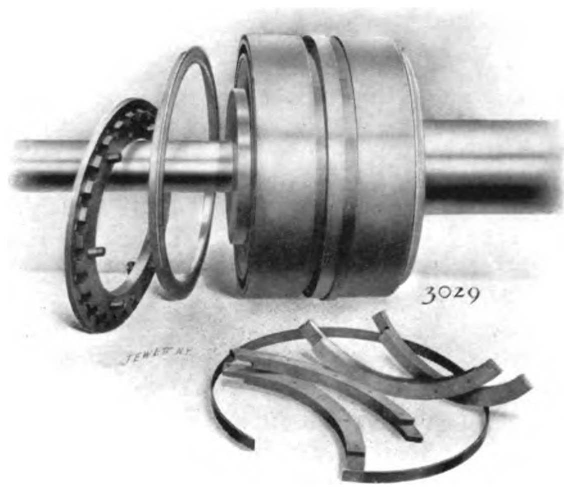
A Single "Hurricane-Inlet" Valve

The "Hurricane-Inlet" Valve

The "Hurricane-Inlet" Valve, standard on most of the Ingersoll types of Ingersoll-Rand Compressors, is a development of the original Piston Inlet Valve. It retains the "piston air inlet tube" feature of the latter, but differs in some very important details, resulting in a marked improvement. Each valve—one on each piston face—is a continuous ring of high-carbon, oil treated steel, forged without welds and turned to a light "T" section with no holes, slots or weak places. The port is an annular opening in the piston face, of unusual area and with no obstructions whatever. The bar of the "T" is the valve face seating over the port. The upright of the "T" is the guide section sliding on a steel guide plate bolted to the piston face and made with openings so that the valve is double-ported.

The valves travel with the piston, the one in front closing first by its inertia and remaining closed under air pressure. The valve behind, as soon as the piston starts, drops back against its stop, making a full opening maintained until the piston stops, when the valve slides gently to its seat. The inlet valve cannot open until the clearance air is expanded to atmosphere, so there can be no escape of air already compressed. The valve being

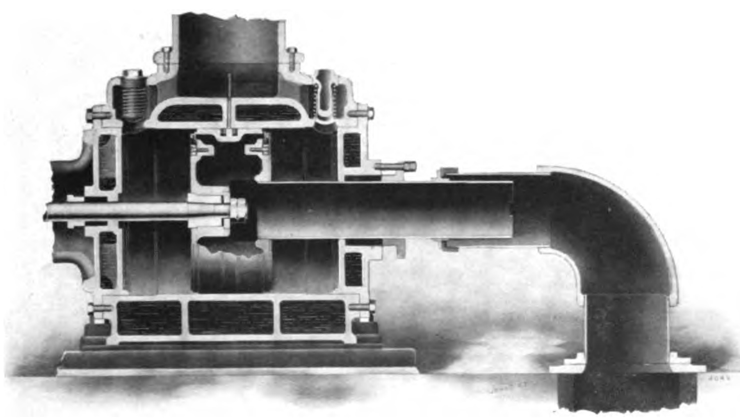
very light and the travel very short, there is no shock and practically no wear. When the valve moves it opens full, stays open for the full stroke and closes instantaneously. Nothing can be more simple and more positive than this valve action.



A "Hurricane-Inlet" Piston, with its Component Parts

The valve is free to turn around its guide ring and does actually turn in operation, never seating twice in succession in the same position and being thus automatically self-grinding. The removal of any discharge valve on the cylinder exposes the "Hurricane-Inlet" Valve, which can be turned around by hand and examined over its entire circumference without removing the cylinder head. There are only two moving parts, actuated solely by momentum and air pressure.

Reference to the illustration above shows the "Hurricane-Inlet" Valve around the piston rod, between the guide plate



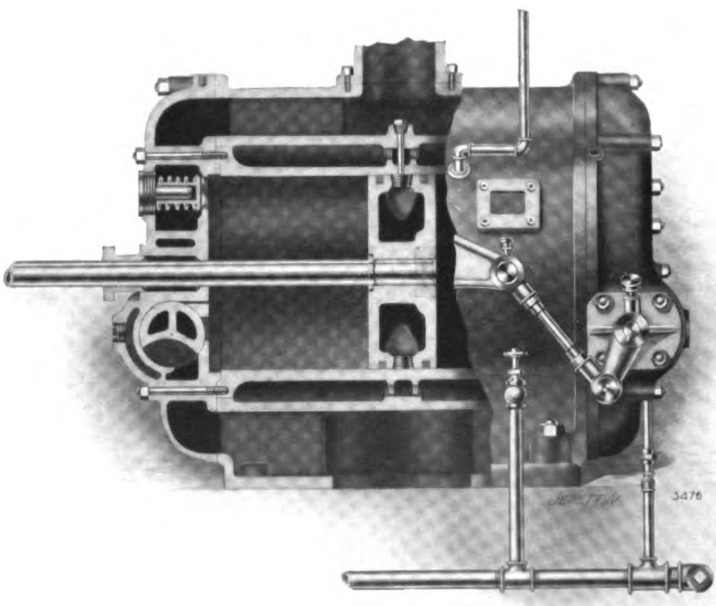
Section of a "Hurricane-Inlet" Air Cylinder, with Cushioned Direct Lift Discharge Valves

and the piston One of the segmental piston rings is in the foreground. Nothing about a compressor gives less trouble than the piston rings, which stay in place until worn out Yet the "Hurricane-Inlet" Valve, as shown in this illustration, is even more simple than a piston ring.

The intake area afforded by the "Hurricane-Inlet" Valve is 12 to 15 per cent of the total cylinder area. The construction admits cool air, the intake air entering through the inlet tube which is constantly cooled by contact with the jacketed cylinder head. The air piston and valves are cooled by continuous contact with the cold cylinder walls. The air is admitted in a solid column and everywhere encounters cool metal. Its temperature cannot be perceptibly raised in the fraction of a second required for a complete stroke.

The use of the "Hurricane-Inlet" Valve permits the most thorough cylinder jacketing possible, not only improving the compression efficiency but resulting in a sustained tightness of all working parts due to the better lubrication.

No valve gives a larger output of compressed air than the "Hurricane-Inlet." Compressors with "Hurricane-Inlet" Valves have an unusually large capacity per unit floor space



A "Rand-Corliss" Inlet Valve Cylinder, Half in Section, with "Imperial" Direct Lift Discharge Valves

because the construction permits a higher speed without undue loss than has generally been considered practical. This means more air admitted and compressed per minute, the high volumetric efficiency already mentioned being maintained at high speeds.

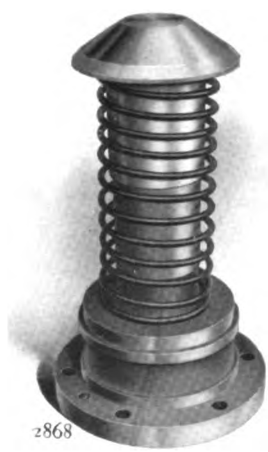
Rand-Corliss Inlet Valves

The Rand-Corliss Air Inlet Valve, used on certain "Rand" and "Ingersoll" types of Ingersoll-Rand Compressors, is the best application of the Corliss movement to air cylinders on the market. The valves themselves are of unusually large diameter and the working pressure is always distributed over the entire valve surface, which is almost precisely a half circle. This pressure, moreover, is always central, so that there is no tendency to wear either the edges of the valve or the surfaces with which they come in contact. Ample port opening is provided at the beginning of the stroke, full opening occurring when the piston is moving most rapidly and the correct timing of the closing of the valve ensuring a full cylinder of air. The construction provides short, free and direct passages for the entering air, with the minimum of clearance. The valve adjustments are so fixed that they cannot be deranged by an incompetent attendant, resulting in an incorrect valve movement and loss of efficiency. The construction of the valves, valve bonnets, stems, etc., is very strong; bearings are unusually liberal and lubrication is ample—all of these resulting in sustained tightness, minimum of friction and lowest maintenance cost. The large areas, short passages, correct movement, low clearance, and absence of leakage result in a very high volumetric efficiency.

Direct Lift Discharge Valves

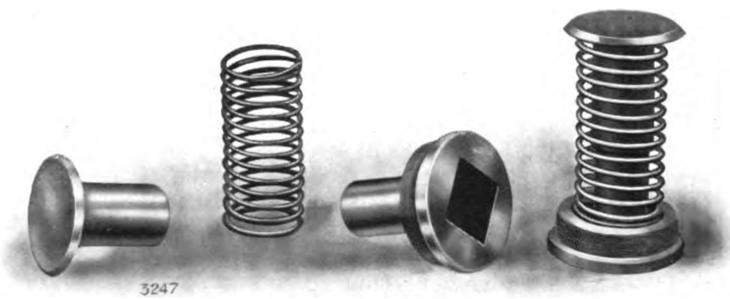
The Ingersoll "Cushioned" Direct Lift Discharge Valve is standard on all but the smallest sizes of Ingersoll compressor types; and the "Imperial" Direct Lift Discharge Valve is used on the Rand line of Ingersoll-Rand Compressors. As they differ only in certain construction details, one description will suffice for both.

They are of balanced, positive, quick-closing type affording the maximum discharge efficiency. The valve proper is machined from selected steel, toughened in oil, annealed and ground to an accurate seat, the cross-section being properly reinforced at points of maximum stress. The projecting lip or rim just above the



A. Complete "Cushioned" Direct Lift Discharge Valve

seat acts under the back-lash of the compressed air to assist the spring in closing the valve instantly and at the right time to prevent any return of the air compressed. The cap or valve guide is accurately ground to a wide and durable guide surface, ensuring that the valve shall return to its seat with precision and sustained tightness. The large diameter of the valve and its broad contact with the guide assure a uniform wear on valve and seat with no tendency to bind. The valve is free to turn and is therefore self grinding. The spiral spring is of the proper pitch and these valves are practically noiseless in operation. There are no webs, bridges or lips obstructing the port passage and the discharge area afforded is about 15 per cent. of the cylinder area. The construction renders entirely unnecessary any removable valve seats, all types of which have been tried out at some time in the Company's experience and abandoned for good reasons.



The Three Parts of an "Imperial" Direct Lift Discharge Valve, with a Complete Valve

Guarantees

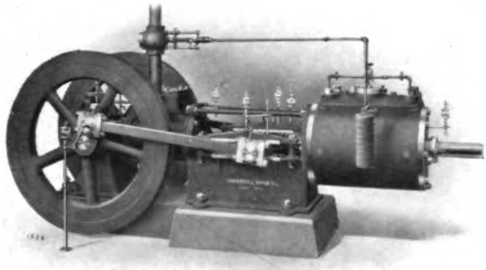
The standing Guarantee of the Ingersoll-Rand Company is to make good at its works, by repair or replacement, any defect in the workmanship or material of its compressors which may develop within one year from date of shipment.

The Ingersoll-Rand Company furthermore furnishes its compressors under a standing guarantee of interchangeability of wearing parts.

The Ingersoll-Rand Company further guarantees that such is the care exercised in the selection of materials, in the workmanship applied, and in the methods of production, that its compressors, under fair treatment and reasonable freedom from abuse, will give better results, with the minimum of delay and expense for repairs, for a longer period than those of any other builder.

Standard Steam Driven Types

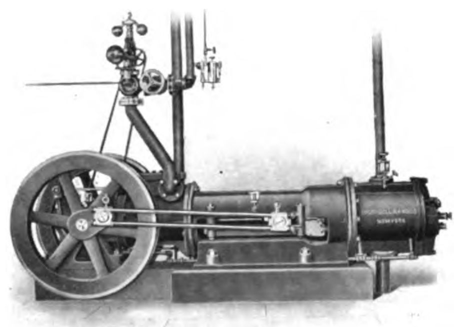
Ingersoll Class "F-1"



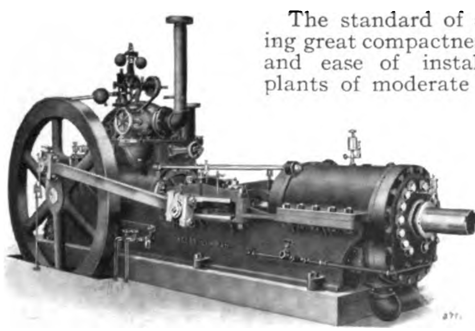
Small, compact compressors of straight line pattern, suitable for stationary or portable plants of small capacity: Simple steam cylinder with plain slide valve: Single stage air cylinder with complete water jacketing: Air valves of approved design and good economy: A type having a wide field where good "all-around" results and steady reliability are desirable: Pamphlet 3009.

Rand Class "RC-1"

Simple, plain, positive, straight line compressors of rugged design and good economy: Simple steam cylinder and single stage jacketed air cylinder: Suitable for plants of small or moderate capacity, semi-permanent or temporary in character, under conditions of hard service and ordinary unskilled attendance: Solid, compact, powerful and dependable machines, reasonable in fuel cost and maintenance: Pamphlet 3009.

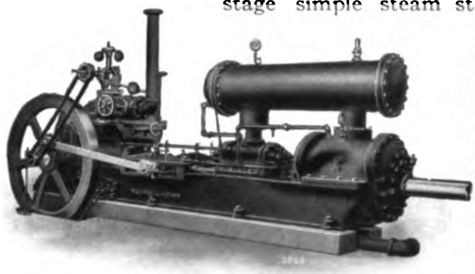


Ingersoll Class "A-1"



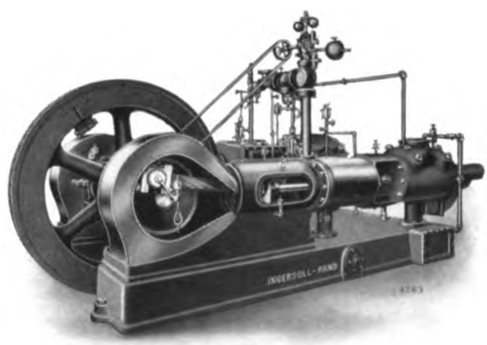
The standard of straight line types, embodying great compactness, moderate cost, simplicity, and ease of installation and operation: For plants of moderate capacity, hard service, ordinary care and semi-permanent character, for mines quarries and shops: Adjustable cut-off steam valves, except on smaller sizes which have plain slide valves: Single stage air cylinder with complete jacketing: Air valves of highest efficiency, giving strictly high-grade performance: Pamphlet 3002.

Ingersoll Class "AA-2"



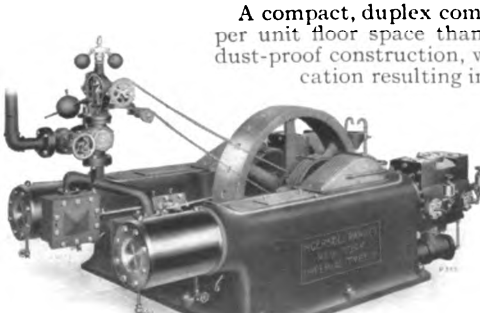
A development of the original "A" type into a two stage simple steam straight line compressor: Notable improvements in important details, making this a new standard of straight line economy, with all the efficiency of compound compression combined with the simplicity, compactness and "unit" quality of the straight line type: Balanced adjustable cut-off steam valves: Air cylinders and intercooler realizing the best two stage ideals: Pamphlet 3003.

Ingersoll Class "HH"



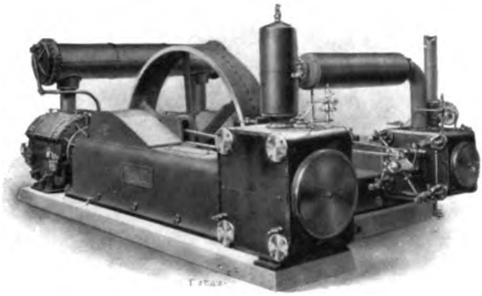
A powerful duplex machine, distinguished by its heavy subbase: Simple or compound, condensing or non-condensing steam cylinders, with Meyer valve gear: Air cylinders duplex or two stage, with complete jacketing and perfect intercooling: A solid, rugged, simple machine, high-class in every detail of design and construction: A "unit" construction, self-contained and automatic in operation: Deservedly one of the most popular types in every class of service: Pamphlet 3018.

Rand "Imperial X"



A compact, duplex compressor with a larger capacity per unit floor space than any other type: Enclosed, dust-proof construction, with automatic "flood" lubrication resulting in the minimum of friction and wear: Steam and air cylinders simple duplex or cross-compound: Completely accessible and as easily installed and maintained as the simplest straight line type: A compressor of great staying power, automatic in operation: Preeminently the machine for hard, "knock-about" service: Pamphlet 3011.

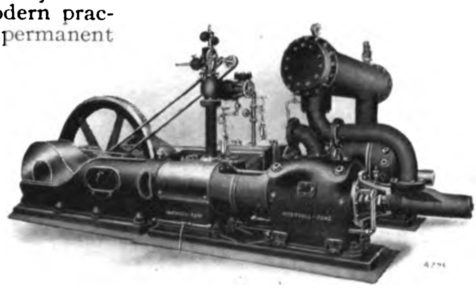
Rand "Imperial-Corliss"



A development of the original "Imperial" type, to secure Corliss steam economy at high speeds: A high-duty machine in the best sense, with modified Corliss steam valves, Rand-Corliss air inlet valves and "Imperial" Direct Lift discharge valves: A superb type, newly designed throughout for high sustained economy at every point: Enclosed "flood" lubrication of every wearing part: A compressor always to be relied upon for high-grade results: Pamphlet 3013.

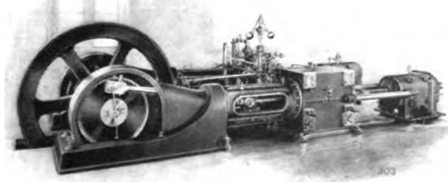
Ingersoll Class "O"

A duplex compressor new in every detail and representing the most modern practise: For semi-permanent or permanent plants of moderate or large capacity, where the best results are to be maintained: Enclosed, dust-proof construction, with a system of "flood" lubrication for every wearing surface: An unusually heavy, massive design throughout, intended for the very best performance under all conditions of operation: The latest embodiment of thirty-eight years of compressor building: Pamphlet 3006.

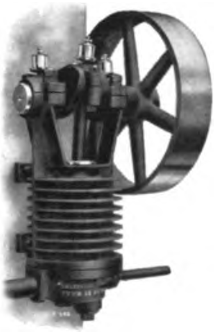


Ingersoll-Rand "Corliss"

A Corliss engine-driven compressor of the highest refinement of design, preeminent in its class for large permanent or semi-permanent plants where the highest attainable economy is essential: The machine which delivers compressed air at the minimum cost, combining the best steam engine and compressor practise, for results covering not months merely, but years of high-duty performance: Pamphlet 3005.



Standard Power Driven Types

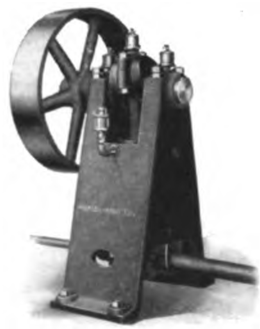


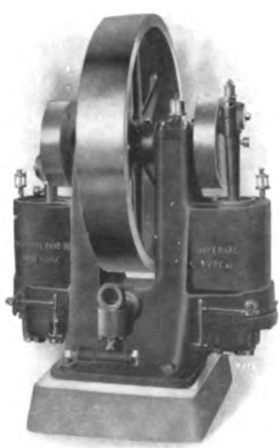
Rand "Imperial Baby"

A sturdy little machine representing the acme of simplicity: Single-acting, air-cooled cylinder, giving good economy at the moderate pressures and intermittent service for which this type is intended: Ordinarily built with a single belt wheel and bolted to a wall or post, but sometimes furnished with special frame for electric gear drive: Pamphlet 3010.

Rand "Imperial Junior"

A vertical, single-cylinder, single-acting compressor of the same capacity as the "Imperial Baby," but with a water-jacketed air cylinder: Built either with a subbase, with lugs for bolting to wall or post, or with a special frame for gear drive from a motor: A sturdy and efficient little machine for purposes where a limited capacity and ordinary pressure are required, with a steady demand: Pamphlet 3010.

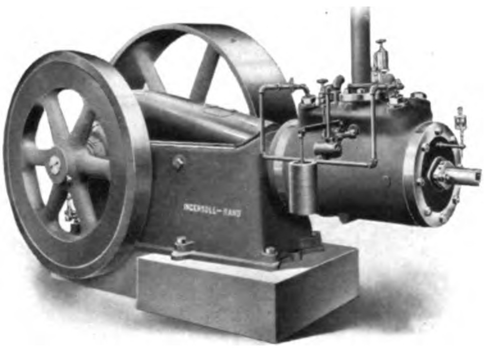




Rand "Imperial XI"

A duplex, vertical, single-acting machine, built for single or two stage compression: Water-jacketed air cylinders and air valves of correct design, giving good economy and steady reliability: A very compact design, requiring the minimum of floor space and accessible on every side: Especially adapted to shops, mills, foundries, factories and all installations of small capacity: A solid, powerful construction, with the minimum of parts and bearings, and a sturdy dependability: Pamphlet 3010.

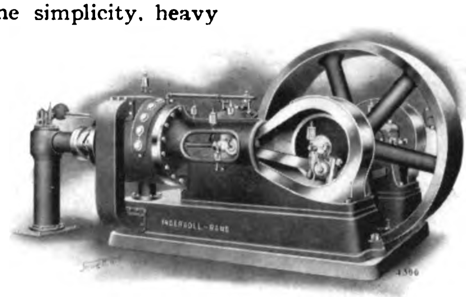
Ingersoll Class "EE-1"



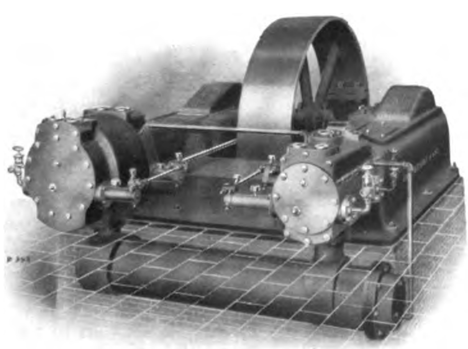
A straight line model representing the best design and construction applied to small machines: An enclosed construction excluding dirt and grit, with "splash" lubrication of every important bearing: Single stage air cylinder, with every provision for economical simple compression: Simple and compact, efficient and thoroughly well-built, adapted to a wide variety of uses: Suitable for small stationary or portable plants, driven from any source of power: Pamphlet 3010.

Ingersoll Class "JJ"

A modification of the "HH" steam-driven type for power drive, retaining the distinctive subbase and "unit" construction: Marked by extreme simplicity, heavy construction, powerful design, self-contained character, and a very high mechanical and compression efficiency: Adapted for driving from any prime mover, by any of the approved methods of connection: Air end duplex or two stage: A very popular type enjoying an increasing demand: Pamphlet 3019.

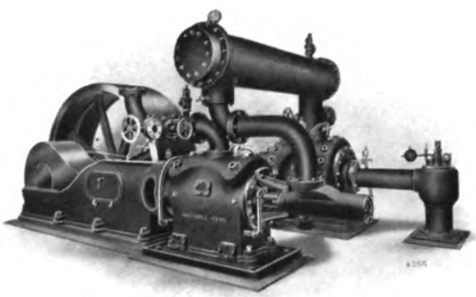


Rand "Imperial XB"



A power-driven machine with the characteristic features of the "Imperial X" pattern, with a heavy subbase and a central flywheel: Automatically self-regulating, with a "flood" system of lubrication throughout and an enclosed construction: A very large capacity combined with very small dimensions, adapting it to locations with limited floor space: A structure liberally designed throughout for the requirements of power drive from any source and by any method of connection: Pamphlet 3012.

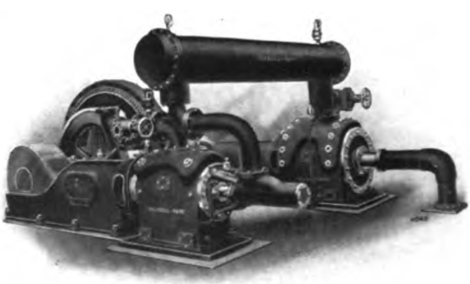
Ingersoll Class "PB"



A power driven modification of the Class "O" steam driven type, for belt or rope drive from an independent prime mover, with every refinement looking to economical compression: Cylinders completely jacketed, inter-cooler of unusual proportions, air valves designed for the best possible efficiency: Wearing parts protected from dust and dirt by the enclosed construction and automatically lubricated by a "flood" oiling system: Pamphlet 3007

Ingersoll Class "PE"

Another modified "O" type, exclusively intended for direct shaft drive by an electric motor, either direct or alternating current, induction or synchronous type: the "Corliss" of the power driven class, embodying every refinement for power drive at minimum operating cost: Special devices for starting and regulating, adapted to the high-class work for which the type is intended: A splendid machine of the most advanced construction: Pamphlet 3008.



High Pressure Compressors

Modifications of various types previously outlined, designed for pneumatic haulage, gas or air storage purposes, experimental use, etc.: As reliable, efficient, and thoroughly standardized for this exacting class of work as the machines for lower pressures: Characterized by notable improvements and distinctive devices which place them in the most advanced position: Pamphlet 3014.

Air Receivers, Pressure Tanks and Moisture Traps

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 9002 December, 1908

THE discharge from an air compressor is more or less pulsating in character; and an air receiver is a "rectifier," so to speak, which receives and absorbs these pulsations and delivers a steady flow to the pipe line. It is, in a very small degree, an accumulator in which excess energy is momentarily stored and withdrawn. But it cannot be relied upon as an effective power storage in any large degree.

The air receiver cannot be too large, nor can there be too many receivers, provided that leakage is carefully avoided in the connections. Large receiver capacity is especially useful in work of an intermittent character, such as running rock drills, pneumatic tools, etc. It makes the problem of regulation easier and assists the governor or regulator of the compressor in maintaining a steady pressure.

As between the vertical and horizontal type of receiver, preference should be given to the former. It should be placed as close as possible to the compressor or aftercooler, and pipe amply large should be used for connecting it up. It is better to make the pipe between compressor and receiver a size larger than that leaving the receiver. In the former section of piping, elbows should be avoided if possible, and wide-sweep bends given preference. **A valve should never be used between compressor and receiver unless the former is protected by a safety valve on the side nearest the compressor.** Each receiver should have a safety or relief valve; and where the receiver is out-of-doors, this relief valve should be piped back into the compressor room to avoid freezing.

There is some cooling of the air in the receiver; and since cooling means condensation of water vapor, the receiver should preferably be placed out-of-doors, where its cooling effect will produce drier air. A smaller secondary receiver or receivers placed along the line at some distance will still further cool and

Vertical Air Receiver
Sizes 1 and Larger

dry the air. Every receiver should have a drain-cock at its lowest point, which should be opened regularly and often for the discharge of accumulated water.

Primary or main receivers, or those next to the compressor, should be so piped up that the air will enter at the top and leave near, but a little above, the bottom. On secondary receivers this arrangement should be reversed. On long pipe line systems small receivers, or moisture traps, should be placed at the low points in the lines, the piping entering and leaving at the top. These will catch the moisture condensed in the lines, which should be withdrawn frequently through a drain-cock.

On page 4 the standard air receivers, pressure tanks and moisture traps of the Ingersoll-Rand Company are listed, with their essential specifications. All are of the best grade of workmanship and material, free from leaks and thoroughly tested.

Sizes 0 to 00 are suitable for machine shops, stone yards, foundries, small air lift plants, and for all places where a small compressor only is used. They are made of the best steel, single riveted, are tested to 165 pounds water pressure, and warranted safe and light under 110 pounds working air pressure. Standard equipment includes safety valve, pressure gage, drain-cock and tapped openings for inlet and discharge pipes.

Vertical Air Receiver
Sizes 0 and 00

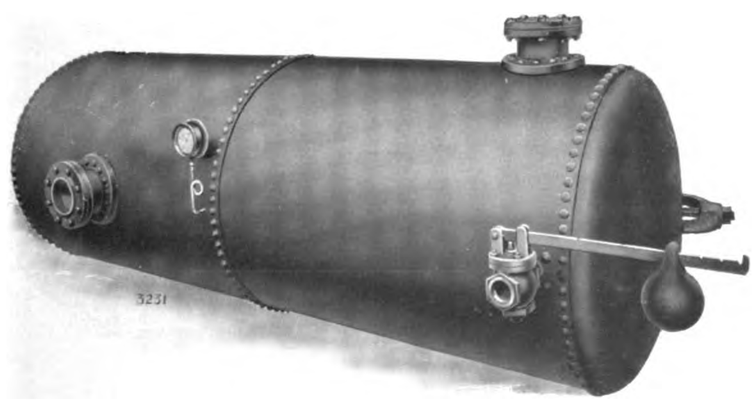
Sizes 1 to 10 are for plants of larger capacity. They are made of the best 60,000-pound t.s. steel, with dished heads and double-riveted side seams, are tested to 165 pounds water pressure and guaranteed for 110 pounds working air pressure. The equipment includes a man-head, safety valve, pressure gage, drain-cock and flanged openings for inlet and discharge.

Sizes 11 to 20 are similar to sizes 1 to 7½, except that they are designed for a working pressure of 150 pounds, tested to 225 pounds water pressure, and made of heavier steel.

Sizes 21 to 28 are for working pressures of 300 pounds and are tested under water pressure to 450 pounds. Sizes 29 to 37 are designed for working air pressures of 500 pounds, being tested to 750 pounds water pressure.

All of the receivers tabulated can be furnished in either vertical or horizontal pattern, except sizes 9 and 10, which are intended to be used as moisture traps in air lines and are supplied only in horizontal pattern. For openings of 4-inch pipe size or smaller, a threaded flange is riveted to the shell, as shown in the illustrations on page 2. For 5-inch pipe openings and larger a double flange is provided, as shown in the illustration on page 3.

The sizes for inlet and discharge given in the tables are MAXIMUM. When necessary, they may be reduced on the smaller sizes by reducing plugs and on sizes using flange connections by a reducing flange. If special sizes of openings smaller than standard are specified in the original order, they will be furnished without extra charge, but there will be a delay in shipment.



Horizontal Air Receiver, Standard Construction

Ingersoll-Rand Air Receivers, Pressure Tanks and Moisture Traps.

For 110 Pounds Working Pressure. Tested to 165 Pounds Water Pressure.

Telegraph Name	No. of Size	Diameter, Inches	Length, Feet	Contents Cubic Feet (about)	Thickness of Shell, Inches	Thickness of Heads, Inches	Weight Pounds (about)	Diameter of Safety Valve, Inches	Diameter of Inlet and Discharge Openings, Inches	Compressor Capacity Receiver is best Adapted for in Cubic Feet Free Air per Minute.
Recab.....	0	18	6	10	3/16	5/16	350	1	2½	90
Receda....	00	24	6	18	7/32	5/16	575	1¼	2½	120
Recife.....	1	30	6	29	1/4	3/8	950	1½	3	150
Recogi....	2	36	6	42	1/4	3/8	1000	1½	3½	150 to 200
Recuko....	3	36	8	56	1/4	3/8	1350	1½	4	200 to 300
Recala....	4	42	8	77	9/32	3/8	1750	2	5	300 to 500
Receme....	5	42	10	96	9/32	3/8	2000	2	6	500 to 700
Recono....	6	48	12	150	11/32	7/16	3000	2½	7	700 to 1200
Recupu....	7	54	12	190	3/8	7/16	3300	2½	8	1200 to 2100
Recura....	7½	60	14	275	13/32	1/2	5500	2½	9	2000 to 3000
Recare....	8	66	18	437	7/16	9/16	7500	2½	10	3000 and over
Reciso.....	9	24	6	18	7/32	5/16	625	1½	4	These are only furnished in horizontal style and are used as moisture traps in air lines.
Recoza....	10	36	6	42	1/4	3/8	1100	1½	6	

For 150 Pounds Working Pressure. Tested to 225 Pounds Water Pressure.

Telegraph Name	No. of Size	Diameter, Inches	Length, Feet	Contents Cubic Feet (about)	Thickness of Shell, Inches	Thickness of Heads, Inches	Weight Pounds (about)	Diameter of Safety Valve, Inches	Diameter of Inlet and Discharge Openings, Inches	Compressor Capacity
Redada....	11	18	6	10	1/4	1/4	400	1	2½	135
Redarg....	12	24	6	18	9/32	3/8	725	1¼	2½	180
Rededi....	13	30	6	29	5/16	3/8	975	1½	3	225
Redepo....	14	36	6	42	11/32	3/8	1300	1½	3½	225 to 300
Redet.....	15	36	8	56	11/32	3/8	1600	1½	4	300 to 450
Redige....	16	42	8	77	3/8	7/16	2075	2	4	450 to 750
Reditu....	17	42	10	96	3/8	7/16	2550	2	5	750 to 1050
Redoma ..	18	48	12	150	7/16	1/2	4000	2½	6	1050 to 1800
Redorn....	19	54	12	190	7/16	1/2	4650	2½	7	1800 to 3000
Reduz.....	20	60	14	275	1/2	9/16	7350	2½	8	3000 to 4500

For 300 Pounds Working Pressure. Tested to 450 Pounds Water Pressure.

Telegraph Name	No. of Size	Diameter, Inches	Length, Feet	Contents Cubic Feet (about)	Thickness of Shell, Inches	Thickness of Heads, Inches: Top	Bot'm	Weight Pounds (about)	Diameter of Safety Valve, Inches	Diameter of Inlet and Discharge Openings, Inches	Compressor Capacity
Reebok....	21	18	6	10	5/16	3/8	7/16	560	1	2½	250
Reeder....	22	18	8	14	5/16	3/8	7/16	725	1¼	2½	330
Reege.....	23	24	6	18	3/8	7/16	7/16	1025	1¼	2½	330
Reela.....	24	24	8	24	3/8	7/16	7/16	1250	1½	2½	410
Reemp....	25	30	6	28	7/16	1/2	1/2	1400	1½	3	410
Reepo.....	26	30	8	39	7/16	1/2	1/2	1750	1½	3	410 to 550
Reespe....	27	36	8	56	1/2	9/16	9/16	2600	1½	3	550 to 825
Reexpo....	28	36	10	70	1/2	9/16	9/16	3325	2	4	825 to 1200

For 500 Pounds Working Pressure. Tested to 750 Pounds Water Pressure.

Telegraph Name	No. of Size	Diameter, Inches	Length, Feet	Contents Cubic Feet (about)	Thickness of Shell, Inches	Thickness of Heads, Inches: Top	Bot'm	Weight Pounds (about)	Diameter of Safety Valve, Inches	Diameter of Inlet and Discharge Openings, Inches	Compressor Capacity
Refach....	29	18	6	10	7/16	1/2	5/8	850	1	2½	400
Refajo....	30	18	8	14	7/16	1/2	5/8	1075	1¼	2½	500
Refera....	31	18	10	17	7/16	1/2	5/8	1320	1¼	2½	600
Refig......	32	24	6	18	9/16	5/8	5/8	1650	1¼	2½	500
Refod.....	33	24	8	24	9/16	5/8	5/8	2100	1½	2½	600
Reforz....	34	24	10	30	9/16	5/8	5/8	2650	1½	3	750
Refrac....	35	30	6	28	5/8	11/16	11/16	2725	1½	3	750
Refuga....	36	30	8	39	5/8	11/16	11/16	2825	1½	3½	900
Refuto....	37	30	10	49	5/8	11/16	11/16	3550	2	3½	1200

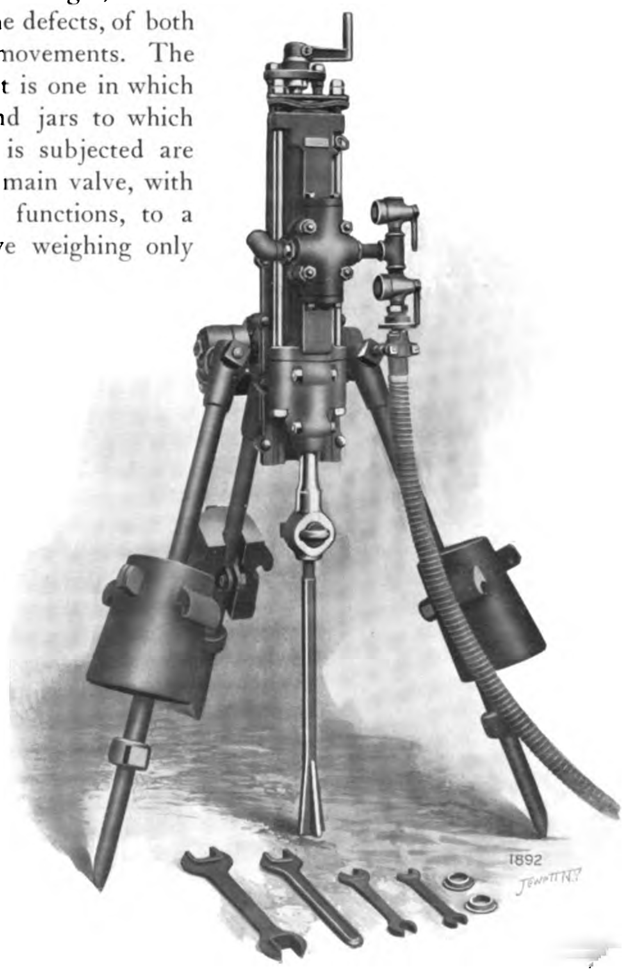
"SERGEANT" ROCK DRILLS

INGERSOLL-RAND COMPANY

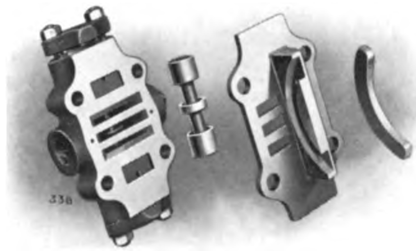
11 BROADWAY, NEW YORK

Form No. 4202 December, 1910

THE "Sergeant" drill is a successful combination of the "independent" air-thrown valve of spool type, with an improved modification of the tappet action. It retains certain advantages, while avoiding the defects, of both of these earlier valve movements. The "Sergeant" movement is one in which the strains, shocks and jars to which the tappet or rocker is subjected are transferred from the main valve, with its vital and delicate functions, to a smaller auxiliary valve weighing only a few ounces, specially designed to withstand this service to best advantage and cheaply replaced when worn. But the wear upon it is almost imperceptible, for its bearing surfaces are very large, are highly finished, and are freely lubricated by the oil entering the drill. A valve seat between valve chest and

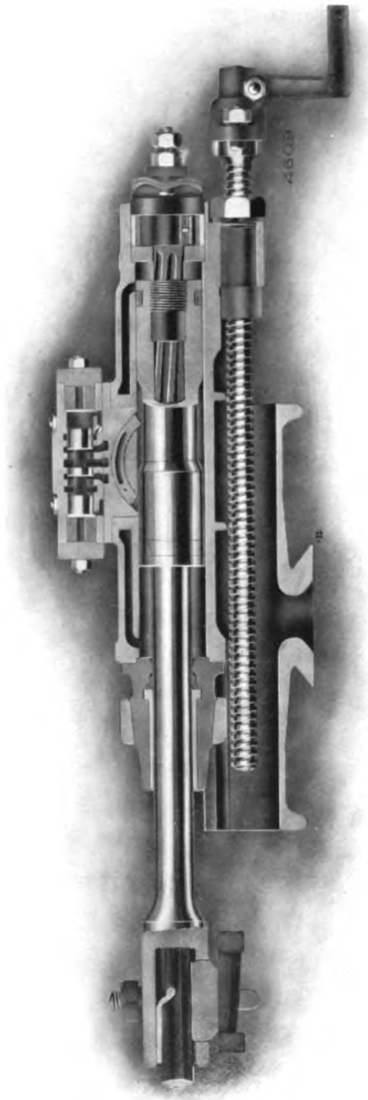


cylinder carries an extension fitting into a recess in the latter. In this extension is milled an arc-shaped groove or slot in which the light auxiliary valve slides freely. The main valve is of the balanced air-thrown spool type, with wearing surfaces ground to a plug fit in a reamed valve chest. One end or other of the auxiliary valve projects slightly into the cylinder bore and is pushed or lifted by the piston in its travel. This movement is perfectly free and very short—only enough to uncover a small port which releases pressure from one end of the main valve; full pressure on the other end then throws this main valve, opening wide the main port and admitting full pressure to the piston for the return stroke.



"Sergeant" Chest, Valves and Parts

Ingersoll-Rand Rock Drills on the Panama Canal



Longitudinal Section of "Sergeant" Rock Drill, Showing Valve Mechanism

The auxiliary valve is simply a trigger which releases the main valve. It is accurately machined from the best tool steel, and is hardened. Being very light, its impact cannot injure or retard the piston; nor is there any of that crowding of the piston against the opposite cylinder walls which has been such a fruitful source of trouble in ordinary tappet drills and responsible for the rapid wear of rings, pistons and cylinders in machines with ordinary unbalanced, hard-moving tappet motions. Pressure being on the back of the auxiliary valve, continued wear only improves its seating. Its action is quick, positive and perfectly free.

The main valve is accurately ground from hardened steel and is protected by buffers at the end of its travel; breakage is unknown. Being perfectly balanced, it moves freely with little wear, and the full port opening is secured almost instantly. The combined action

Six Ingersoll-Rand Drills at the Alpha Portland Cement Company's Quarry

of these two valves is such that admission and exhaust ports, instantly opened, *retain full opening to the end of the stroke.* There is therefore no cushion pressure to retard the stroke and diminish the blow; and for a given diameter of cylinder and a given weight, this is by all odds the most powerful drill made.

The "Sergeant" drill has a wide variation of stroke, secured simply by "cranking" the machine forward, without any valves or other regulating devices. The blow is absolutely dead, and no machine of equal cylinder diameter can match it in its effective penetrating quality. The ability of this drill to run on a very short stroke is of enormous advantage in starting a hole on an oblique surface and in avoiding a glancing blow, with consequent breakage of the starter shanks; it also admits of the hole being quickly started without "funneling" or "rifling." This feature is of vital importance under many drilling conditions — such as working through seams, in shelly or caving material where pebbles fall under the bit, in crevices or alternate layers of hard and soft rock, and in many other circumstances familiar to drill runners and likely to be encountered anywhere. The drill also "muds" or cleans the cuttings out of the hole in a most effective manner.

Another most important advantage of the variable stroke of the "Sergeant" drill, and one appealing to the practical man, is that it makes possible the use of odd steels which, by wear or breakage, have become of uneven length. Some other drills cannot use steels differing more than two inches from standard lengths. Steels

Ingersoll-Rand Rock Drill on Harbor Improvement Work, Fishguard, Wales

shortened as much as five inches can be used with this drill. This fact allows more leeway in starting the machine after changing steels, without moving the setting, wasting time in getting an odd steel shortened, or hunting up a steel of the right length. Drills of other types are compelled to start on practically full stroke.

Another valuable feature of design in this drill is that the valve action is not dependent upon the condition of cylinder, piston or rings. It has an absolutely positive and independent valve movement. Other types of independent valve machines operate well *only* so long as the piston is a good plug fit in the cylinder; and, cylinder walls, piston and rings being inevitably subject to wear and consequent leakage, the valve action is soon at a serious disadvantage and requires very extensive repairs or entire rebuilding. The auxiliary valve, in striking contrast to this, will perform its functions perfectly,

Ingersoll-Rand Drills on Quarry Bars Digging Foundations for New York Edison Building

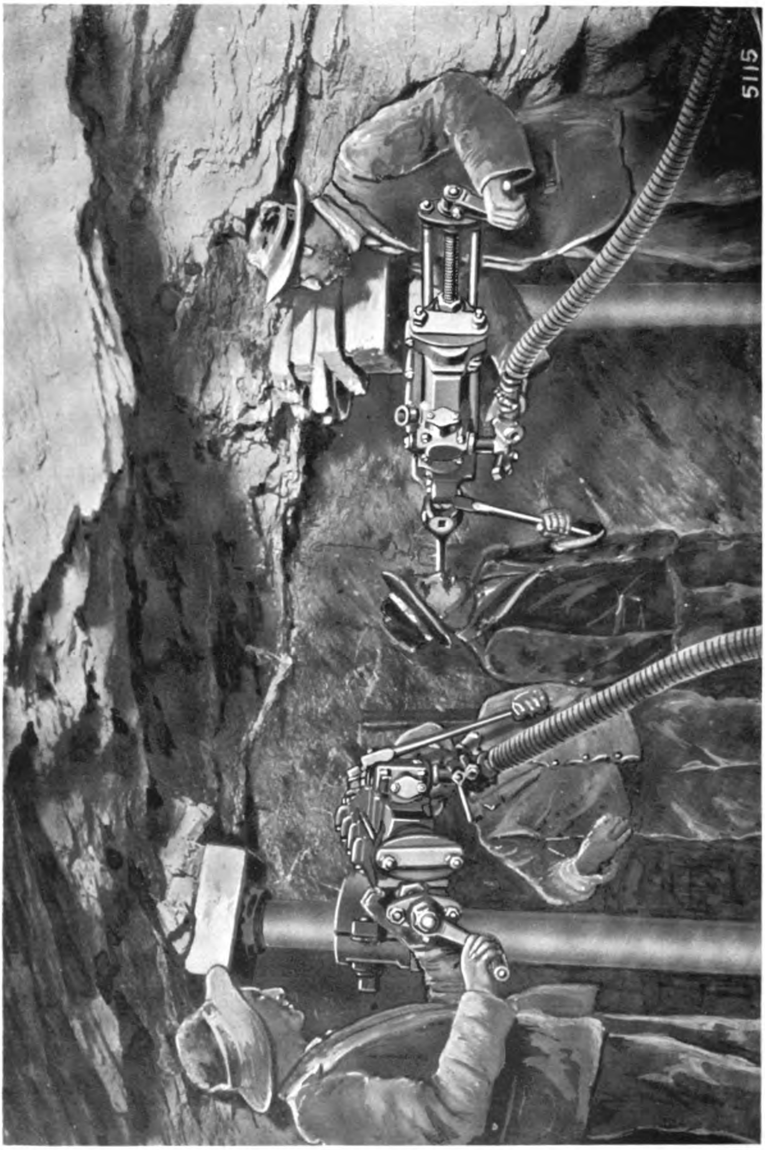
even with a loose piston or with the rings entirely absent from the machine. To this exclusive feature of design is largely due the sustained capacity of this drill. But it is almost unnecessary to state that a tight piston is always desirable in the interest of highest efficiency and good air or steam economy.

Remarkable records have been made in the hardest rock by drills of this type; performances just as remarkable have been noted in soft and medium rocks — facts leading to the belief that this can be justifiably called an "all-round" drill. For rapid tunnel driving and hard service anywhere, it is without doubt the best machine today. It is a rapid and economical drill under almost any condition, except where its dead, stunning blow loses effect in "springy" or elastic material. The best results are always secured with live, active air; but dry steam brings out a good performance also. It is a simple, rugged machine and the frequent remark about it is that "any blacksmith can keep it in good running order." All bolts and threads are standard; there is nothing "special" about it. In long-continued service under the most severe conditions, its repairs have been found to be less than upon any other model of drill; while recent improvements in details have added to its economy and power.

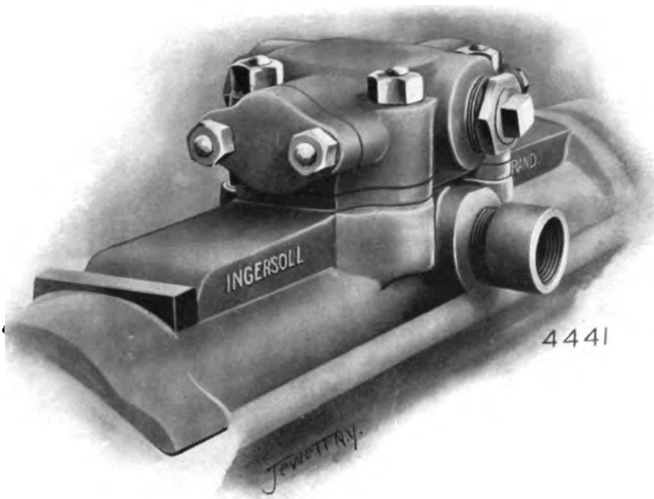
The "Sergeant" drill is today the most powerful, most reliable and most effective independent valve machine on the market, and the most economical in the matter of repairs and air consumption.

Experience under various conditions has developed a variety of drill chucks, valve chests and drill shells which are available for use with the "Sergeant" drill and are offered as options, to be furnished on order. These are illustrated and described on pages 9 to 19 following. Attention is called to the particular advantages of each of these types, as they may be found valuable, and to be preferred by the trade, for certain classes of work and under certain conditions. None of them are experimental, but all have been thoroughly tried out in practical work and are known to be right.

Detailed specifications of the "Sergeant" drill in all its types and sizes are tabulated on page 21.



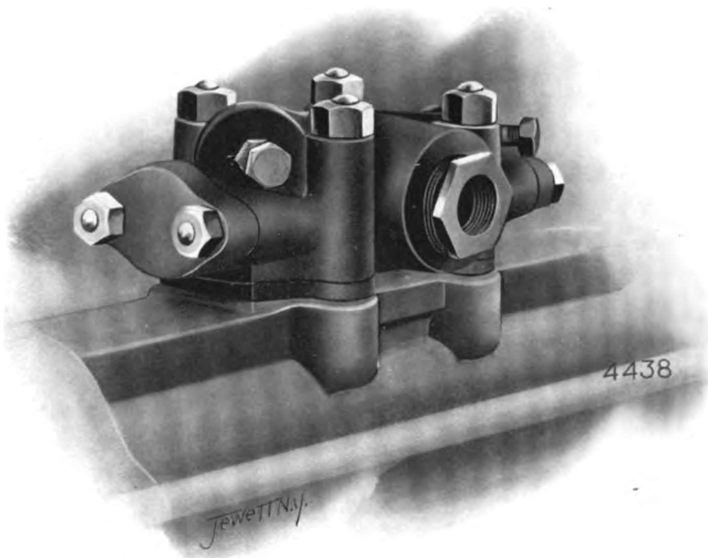
Two Ingersoll-Rand Drills in the Jungfraubahn Tunnel



The Standard "Sergeant" 24 and 44-Type Valve Chest

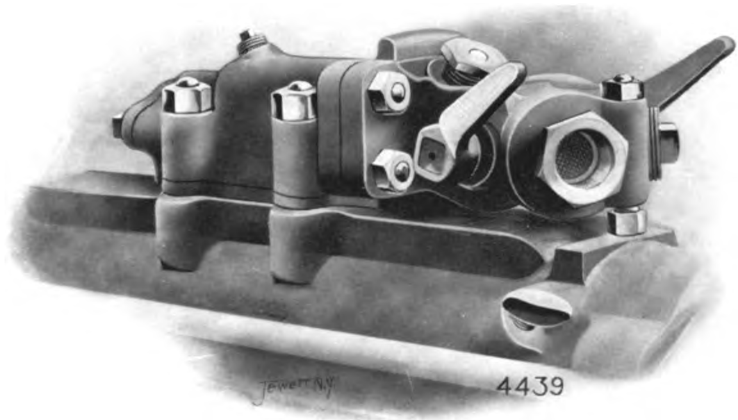
"Sergeant" Valve Chests

The "24" *and* "44-*Type*" *Valve Chest* shown in the illustration above is considered the standard chest for "Sergeant" drills, and is always furnished unless the order distinctly specifies some other type. This is a very simple, compact device, of great durability. It has two air connections, one on either side, so that the hose can be attached on the most convenient side. The air inlet opening not in use is closed by a plain screw plug. Inlet and discharge openings are fitted with removable bushings which protect the threads in the chest and cylinder from injury by repeated screwing and unscrewing of connections. The removal of two nuts on the end of the chest releases the chest cover so that the main valve can be inspected or removed without taking the chest from the cylinder. Access is had to the auxiliary valve by removing the nuts on the studs holding the chest to the drill.



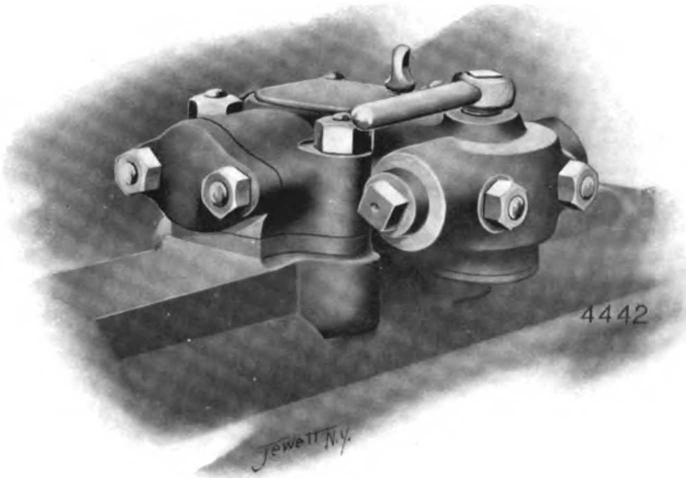
The "Sergeant" 44-52-Type Valve Chest

The "44-52-Type" Valve Chest here illustrated is an improvement on the "52-Type" adjustable or compensating chest used for so many years on the "Sergeant" drill. It is a special device, which is furnished only on specific order. The distinguishing feature is that it provides a means for compensating for the wear in the main valve. Any spool valve, after long service, allows some air to escape past it, more and more affecting the operation of the drill. Without special adjustment such as this chest affords, such a condition can be corrected only by substituting a new valve and chest. In the "44-52" chest, however, an adjusting screw at either end permits compensation for leakage in the main valve, so that the operation of the drill is not impaired. The character and quality of the blow can also be varied, in the hands of a skillful man, for different drilling conditions by means of these adjustments. Full directions for adjusting the "44-52" chest accompany each drill so equipped.



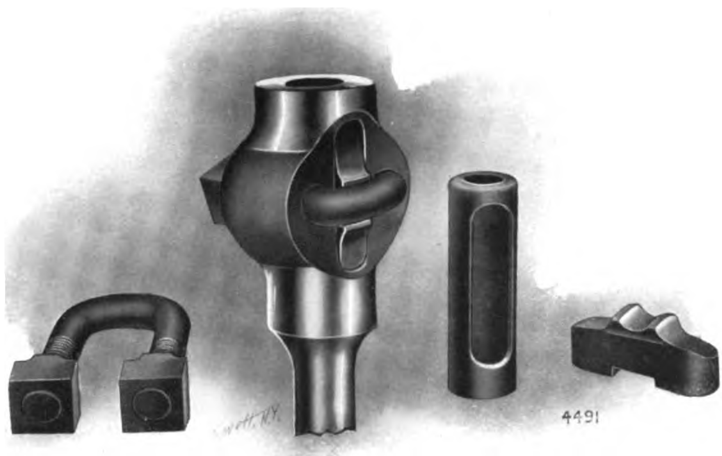
The "Sergeant" 15-88-Type Valve Chest

The "15-88-Type" Valve Chest illustrated above is another of the special chests developed by the Company in connection with the "Sergeant" drill. It differs from the standard "24" chest only in having a throttle valve rigidly bolted to the rear of the chest instead of being placed in the air inlet connection. Two handles are provided for this throttle, so that it can be manipulated conveniently from either side of the drill. The air inlet connections — two of which are provided, one on each side — point backward along the cylinder, so that the hose connection does not take up space beside the drill. The inlet openings are screened against the admission of foreign matter to the chest. The regular rock drill oiler, coupled in the air supply, cannot be conveniently used with this chest, so a ball oiler is provided in the back and top of the chest, through which oil may be fed as needed. The air inlet and exhaust openings are bushed. This chest is particularly adapted for heading or narrow drift work where it is desirable to mount the drill close to the roof or wall.



The "Sergeant" 15-24-Type Valve Chest

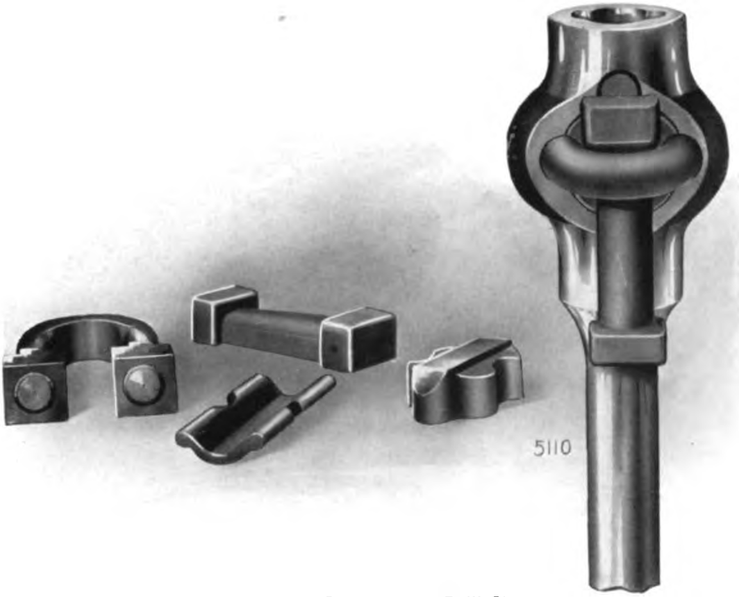
The "15-24-Type" Valve Chest is another special chest furnished only on the customer's order. It has been used extensively in South Africa, but has also been favorably received in other mining countries. In essentials it is the standard "24" type of chest, with a throttle valve bolted to one side of the chest casting. The throttle has a single handle, at the top, with air inlet openings at front and rear. One or the other of these is closed by a screw plug, the hose when connected lying close to, and parallel with, the drill, taking up very little room at the side. Two studs hold the throttle to the chest. Two studs at each end of the chest hold the chest covers in place, the removal of either of which permits withdrawing the main valve for examination or removal. The four studs holding the chest to the cylinder also hold in place the auxiliary valve plate, containing the auxiliary valve. The main valve is accessible without taking the chest from the cylinder. An opening on top of the chest, closed with a thumb-screw, provides for oiling the machine.



The "Sergeant" 32 Drill Chuck

"Sergeant" Drill Chucks

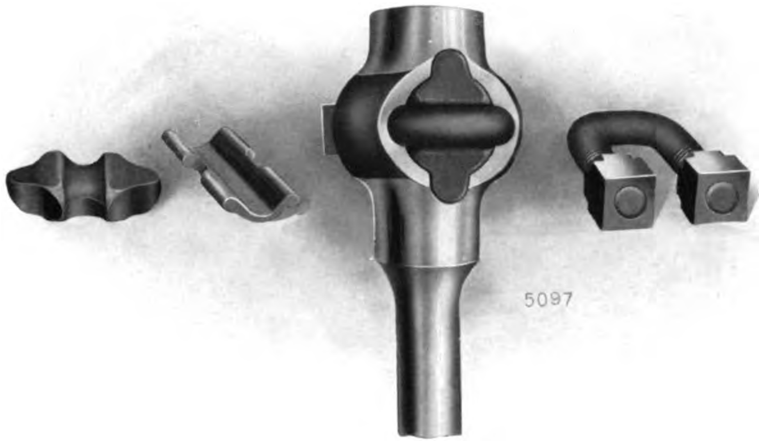
The "32-Type" Chuck which is illustrated above is considered the standard chuck on all "Sergeant" drills, and is always furnished unless the customer specifies some of the other chucks offered as options and described later. The "32" chuck is adapted only for round-shank steels and in this work has proved to be a powerful, reliable chuck, giving perfect satisfaction. The chuck forging is very strong and heavy, treated in oil with the rest of the piston and therefore very tough and strong. The bore is large enough to take a hardened steel bushing, which is pressed in place and which receives the steel shank. This bushing can be removed and replaced when worn. The chuck key is of hardened steel and of very generous length, giving a powerful grip on the steel. It is completely recessed in the chuck. The U-bolt is of tough, oil-treated steel, of large cross section, with nuts turned to seat in countersinks in the chuck.



The "Sergeant" 42 Drill Chuck

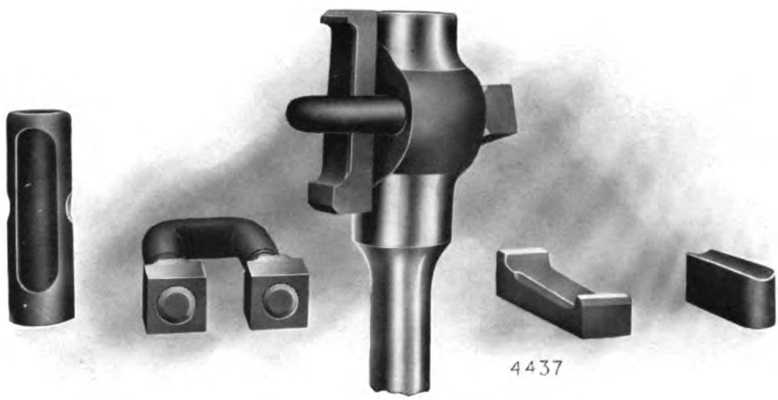
The "42-Type" Chuck here shown is in general appearance very similar to the standard "32" chuck. But in the "42" chuck the plain round bushing is replaced by a half-bushing of hardened steel, which slips in the end of the chuck and is prevented from turning by lips which engage in slots. The U-bolt passing through grooves in the sides of the bushing prevents the latter from slipping out. The chuck bushing is reversible and can be turned end for end when worn. A hardened steel chuck key of ample length grips the steel opposite the bushing; and between key and U-bolt a steel wedge is inserted, so that the steel is tightened or released by a hammer blow on this wedge. The U-bolt nuts are simply for adjustment in maintaining the necessary tightness of the wedge. Both chuck key and chuck bushing are so constructed that either round-shanked steel, or round or octagon steel without shank, can be used. Octagon steel without shank is usually preferred, however. Each size of chuck will also take a small variety in the size of octagon or round steel, without loss of time: an advantage which is not found in any other construction of drill chuck.

The "42" chuck, owing to its large diameter, cannot be used with the "44" shell, described later.



The "Sergeant" 44 Drill Chuck

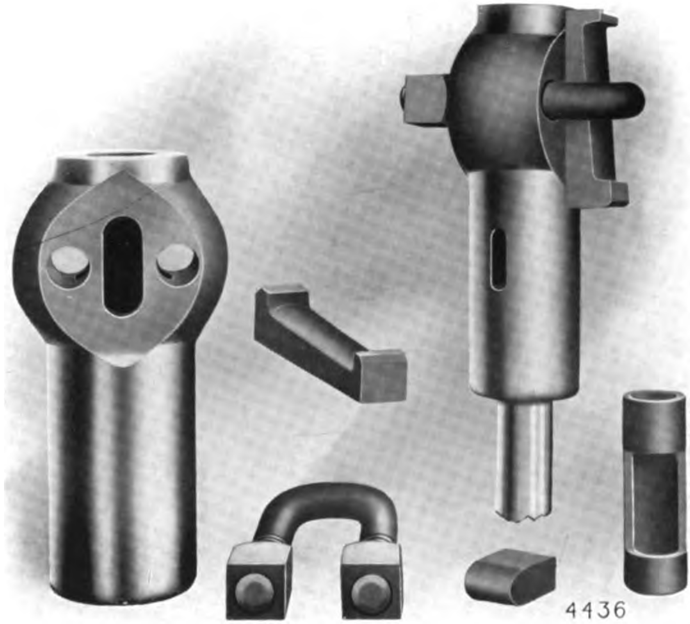
The "44-Type" Drill Chuck shown in the illustration above is a development from, and a modification of, the "42" chuck shown on the previous page. It will be noted in the picture herewith, which illustrates the parts, as well as the assembled chuck, that there is no steel wedge in the "44" type. The chuck key is held directly by the U-bolt and is clamped tight to the steel by the U-bolt nuts on the opposite side. The chuck key is of hardened steel and, instead of being long and narrow, is circular in section, giving a wide bearing in the chuck proper which opposes wear. The "44" chuck bushing is of the same type as that used in the "42" chuck, a half-bushing of hardened steel with lips engaging grooves in the interior of the chuck, which prevents the bushing turning. It is prevented from falling out when loose by grooves on each side which engage the U-bolt. This bushing is reversible and can be turned end for end when worn. With the "44" type chuck either round-shanked steel, or round or octagon steel without shank, can be used. Each size of chuck will also take a small variety in the size of octagon or round steel, without loss of time: an advantage which is not found in any other construction of drill chuck.



The "Sergeant" 14-Type Drill Chuck

The "14-Type" Chuck is another style, shown in the accompanying illustration and furnished only on special order. It is a development of the standard "32" chuck to include the feature of wedge clamping and U-bolt adjustment. A round bushing of hardened steel is used to receive the shank of the steel, an opening in the side of the bushing admitting the chuck key. The chuck key is a long piece of hardened steel, rounded on one side to fit the steel and flat on the opposite side. It recesses in the chuck and bushing. Between U-bolt and chuck key a steel wedge is interposed, giving a powerful grip on the steel by a blow of a hammer and being released by a blow in the opposite direction, with the least loss of time. The arrangement is such that the blow of the drill tends to tighten the wedge. The U-bolt nuts recess in countersunk spaces in the chuck and are used only in adjusting to give the necessary tightness to the wedge, as the parts wear.

The "14" chuck, owing to its large diameter, cannot be used with the "44" shell, described later.



The "Sergeant" 12 Drill Chuck

The "12-Type" Chuck is a fifth style offered as an option with "Arc Valve" Tappet drills and supplied only when the customer specifies it in his order. It has not been so generally used as the types just described, but still finds application in certain fields. This is a detachable chuck, forged from tough steel, oil treated and carefully machined. It is bored in the rear on a long taper, fitting on a corresponding taper on the piston rod of the drill. The operation of the machine tends to drive this chuck tighter on the rod and makes it perfectly rigid. A transverse opening in the chuck admits a taper drift for loosening it from the rod when necessary. In other details the "12" chuck is very similar to the "14" chuck previously described. It uses a hardened steel round chuck bushing, pressed in place; hardened steel chuck key; long driving wedge for gripping and releasing the steel; and a powerful U-bolt providing adjustment for the wedge.

The "Sergeant" 24 Drill Shell

"Sergeant" Drill Shells

The "24-Type" Shell here shown is the standard shell regularly furnished with "Arc Valve" Tappet drills. It is made of a tough malleable iron, strongly reinforced at the proper points. It is fitted with the standard "Sergeant" reversed cone. The guide surfaces are unusually wide, with caps separate and adjustable for wear.

Feed screws are made of tough alloy steel and the feed nut is of hard steel. Standards are forged of high-grade alloy steel. Feed crank and crosshead are of a tough, selected metal.

The "24" shell has proved itself to be a thoroughly practical and successful shell under most working conditions and has given entire satisfaction.

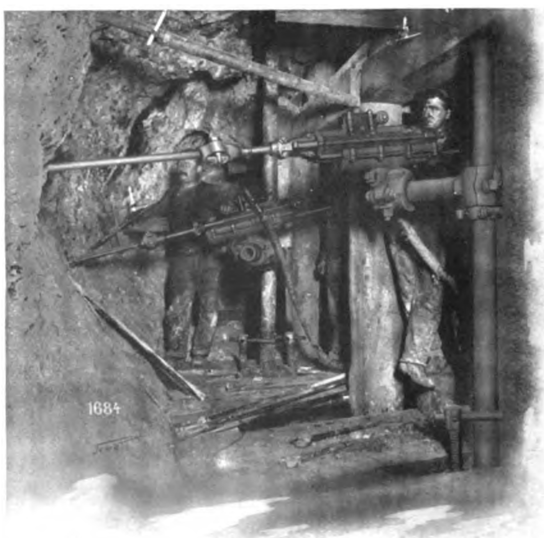
The "Sergeant" 44 Drill Shell

The "*44-Type*" *Shell* was designed to meet the demand for a stronger shell than the "24" type and can now be furnished on special order for all sizes of the "Arc Valve" Tappet drill (see table, page 13). It may be well to repeat here that the "44" shell cannot be used on drills fitted with the "42" and "14" chucks, because of the length of this new shell and the large diameter of these chucks.

The "44" shell is considerably longer than the standard "24" type, giving a correspondingly better support to the drill when at the extremity of the forward feed. Wear on shell guides and guide caps can be taken up by removing liners placed between these parts. There are also shoulders on the outside of the guide caps, beneath which liners are placed to afford lateral adjustment for wear. The standards, which are held in place by nuts and positive lock washers, extend the full length of the "44" shell and the latter is strongly reinforced at points of great stress. In other details, this later shell corresponds closely with the standard "24" shell.

" Arc Valve " Tappet Drills in the Cripple Creek District, Colo.

Over 75 per cent. o. all the Drills used in this district are Ingersoll-Rand machines.

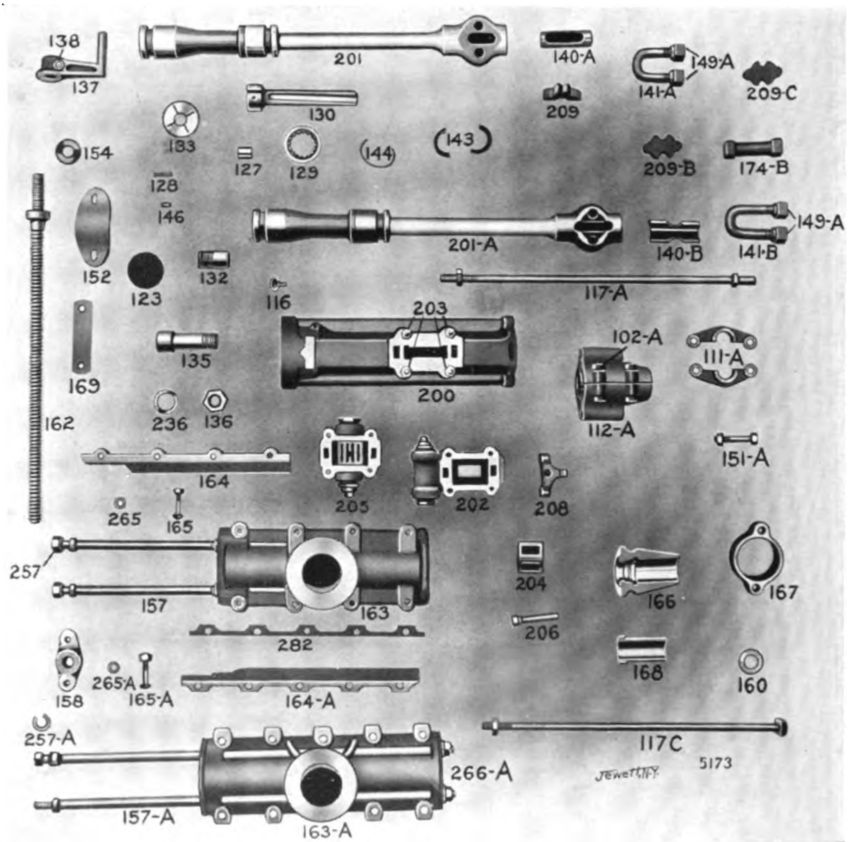


In the seventeen hundred foot level of the Original Mine, Butte, Mont.

Descriptive Table of "Arc Valve" Tappet Rock Drills—(32 Type)

Symbol indicating size and type	A 32	A 50	B 32	C 32	D 32	E 32	F 32
DIMENSIONS:							
Diameter of cylinder ... in.	2¼	2¼	2½	2¾	3⅛	3¼	3⅝
Length of stroke ... in.	5	5	5⅜	6⅝	6⅝	6⅝	7¼
Length of Drill from end of crank to end of piston ... in.	36	36	43	50	50	50	52
Depth of hole drilled without change of bit ... in.	15	15	20	24	24	24	24
Diameter of supply inlet (standard pipe) ... in.	¾	¾	¾	1	1	1	1
Approximate strokes per minute with 75 lbs. pressure at drill ...	500	500	500	375	350	350	300
Depth of vertical hole each machine will drill easily from 1 to ... ft.	6	6	8	10	14	16	20
Diameter of holes drilled as desired, from ... in.	⅝ to 1¼	⅝ to 1¼	1 to 1½	1¼ to 2¼	1½ to 2¼	1¾ to 2¾	1¾ to 3
Average work done per 10 hours in granite down holes, including time lost in setting drill and changing bits ... ft.	70	70	70	70	70	75	75
Diameter of octagon steel used ... in.	¾ or ⅞	⅞ or ¾	1 and ⅞	1⅛ and 1	1¼ and 1⅛	1¼ and 1⅛	1⅜ and 1¼
Size of shanks (diameter and length) ... in.	¾ x 5	⅞ x 5	⅞ x 5	1 x 5½	1⅛ x 6	1⅛ x 6	1¼ x 6
Number of pieces in set of steels to drill holes in depth as stated ...	5	5	5	5	7	8	10
Best size of boiler to give plenty of steam at high pressure ...	5 H. P	5 H. P.	8 H. P.	8 H. P.	8 H. P.	10 H. P.	12 H. P.
Best size of supply pipe to carry steam 100 to 200 ft. ... in.	¾	¾	1	1	1	1	1¼
APPROXIMATE WEIGHTS:							
Drill, Unmounted, with wrenches and fittings, not boxed . lbs.	**140**	**145**	**185**	**270**	**285**	**295**	**415**
Drill, unmounted, with wrenches and fittings, boxed ... lbs.	170	185	230	320	335	345	465
Tripod, without weights, not boxed ... lbs.	85	85	165	165	165	210	275
Tripod, without weights, boxed ... lbs.	120	120	220	220	220	265	340
Holding down weights, not boxed ... lbs.	120	120	270	285	285	330	375
Holding down weights, boxed ... lbs.	140	140	295	315	315	360	420
Drill, tripod, weights, fittings and wrenches, boxed ... lbs.	**430**	**445**	**745**	**855**	**870**	**970**	**1225**
Drill and tripod, without weights and wrenches, not boxed lbs.	215	220	335	419	434	489	673
One set of steels, bundled ... lbs.	35	46	66	101	229	292	536
One length of hose, coupled, boxed ... lbs.	90	90	105	105	105	105	105
SHIPPING MEASUREMENTS (OVER ALL):							
Box with unmounted drill and fittings ... ft. in.	3^{6} 1^{1} 0^{10}	3^{6} 1^{0} 0^{10}	4^{7} 0^{11} 1^{4}	4^{7} 0^{11} 1^{4}	4^{7} 0^{11} 1^{4}	4^{7} 0^{11} 1^{4}	4^{8} 1^{5} 1^{0}
Boxed with tripod ... ft. in.	3^{3} 1^{3} 0^{7}	3^{3} 1^{3} 0^{7}	4^{5} 1^{6} 0^{10}	4^{5} 1^{6} 0^{10}	4^{5} 1^{6} 0^{10}	4^{5} 1^{6} 0^{10}	4^{6} 1^{1} 0^{10}
Box with three weights ... ft. in.	2^{1} 0^{10} 0^{9}	2^{1} 0^{10} 0^{9}	2^{7} 1^{0} 0^{10}	2^{7} 1^{0} 0^{10}	2^{8} 1^{2} 0^{10}	2^{8} 1^{2} 0^{10}	2^{10} 1^{4} 1^{0}
Box with one length of hose ... ft. in.	2^{8} 2^{8} 0^{6}	2^{8} 2^{8} 0^{6}	2^{10} 2^{8} 0^{6}	2^{10} 2^{8} 0^{6}	2^{10} 2^{8} 0^{6}	2^{10} 2^{8} 0^{6}	2^{10} 2^{8} 0^{6}
Prices (f. o. b. Factory or New York) and Telegraph Names:	Kabook	Kaboschir	Kabouters	Kabuff	Kabuiskool	Kabulistan	Kabyle
Drill complete, with wrenches and fittings, without tripod or column ...	$170	$170	$200	$220	$250	$260	$290

NOTE. — *Drill complete* includes drill, throttle, oiler, and wrenches, and does not include mounting, steels, hose or blacksmith's tools. **For full information and prices on Tripods, Columns, Hose, Blacksmith's Tools, and Steels, see Pamphlet No. 9003.**



Duplicate Parts of the "Arc Valve" Tappet Drill

Duplicate Part List for Arc Valve Tappet Rock Drills

Valve Chest and Valve Motion Complete
202 Valve Chest
204 Valve
205 Valve Seat
206 Valve Tappet Pin and Nut
208 Valve Tappet complete (includes parts 208A and 208B)
*208A Valve Tappet Plunger
*208B Valve Tappet Plunger Spring

Cylinder Complete
200 Cylinder Bare or Complete (includes parts 203 and 116)
203 Steam Chest Stud and Nut
116 Thumb Screw

Rotation Complete
130 Rifle Bar
129 Rotation Ratchet
133 Rotation Washer
127 Rotation Pawl
146 Rotation Pawl Plunger
128 Rotation Pawl Plunger Spring

Feed Crank Complete
137 Feed Crank
138 Feed Crank Bolt and Nut

Feed Screw Complete
135 Feed Nut
136 Feed Nut Nut
236 Feed Nut Nut Lock Washer
162 Feed Screw

Piston Complete ("32" type)
132 Brass Nut
201 Piston Bare (includes 140A)
140A Piston Bushing
141A U-Bolt
143 Piston Ring
144 Piston Ring Spring
149A U-Bolt Nut
209 Chuck Key

Piston Complete ("42" type)
132 Brass Nut
201A Piston Bare
140B Piston Half Bushing
141B U-Bolt
143 Piston Ring
144 Piston Ring Spring
174 Chuck Key Wedge
149B U-Bolt Nut
209B Chuck Key

Piston Complete ("44" type)
132 Brass Nut
201A Piston Bare
140B Piston Half Bushing
141C U-Bolt
143 Piston Ring
144 Piston Ring Spring
149B U-Bolt Nut
209C Chuck Key

Shell Complete ("24" type)
163 Shell, Bare (includes parts 157)
157 Standard and Nut
257 Standard Lock Washer
164 Shell Cap
165 Shell Cap Bolt and Nut
265 Shell Cap Bolt Lock Washer
158 Crosshead

Shell Complete ("44" type)
163A Shell Bare (includes parts 157A)
157A Standard and Nut
257A Standard Lock Washer
164A Shell Caps
165A Shell Cap Bolt and Nut
265A Shell Cap Lock Washer
*158A Crosshead
282 Shell Cap Liner
266A Drill Feed Stop

Steam Front Head ("15" type)
112A Front Head, bare (2 pieces) (includes part 102A)
102A Front Head Bolt and Nut
111A Split Gland
151A Split Gland Bolt and Nut
117A Through Bolt and Nut

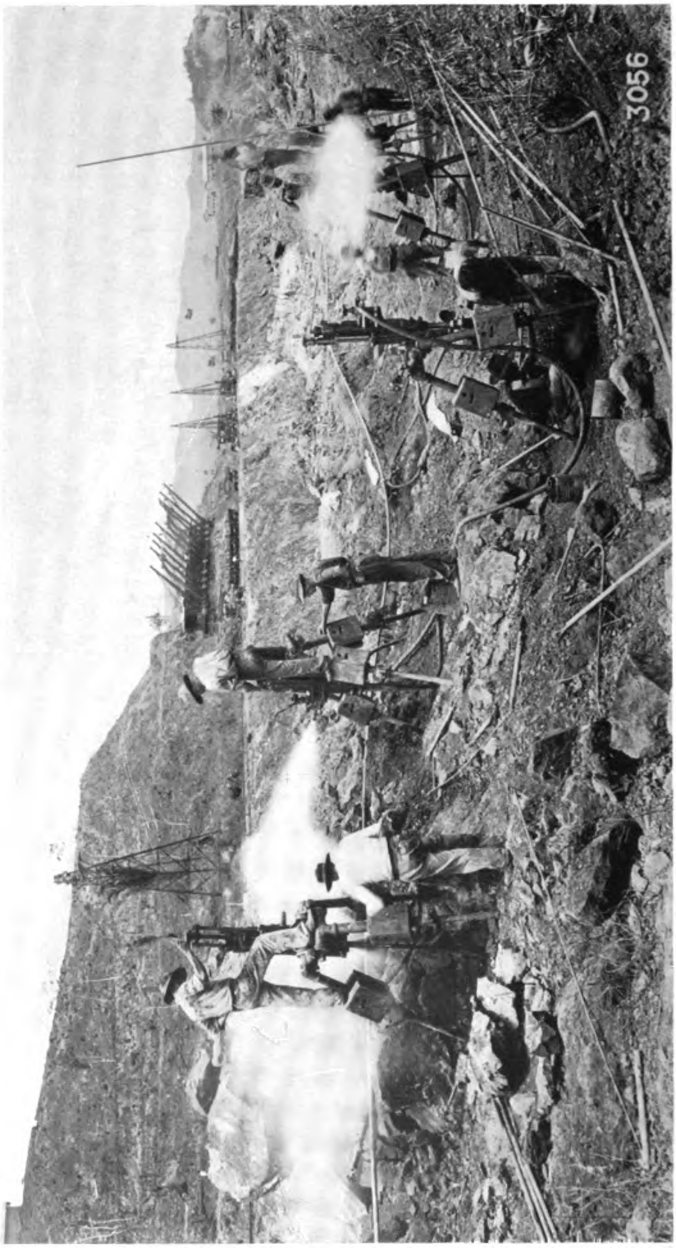
Air Front Head ("15" type)
*159A Air Front Head, 2 pieces (includes parts 102A and 160)
*102A Air Front Head Bolt and Nut
160 Cup Leather
*117B Through Bolt and Nut

Air Front Head ("58" type)
166 Air Front Head, 2 pieces
168 Front Head Bushing, 2 pieces
160 Cup Leather
167 Front Head Sleeve
117C Through Bolt and Nut

Miscellaneous Parts
123 Back Head
152 Cushion Spring
169 Cushion Spring Strap
154 Feed Crank Washer

Parts marked (*) not shown in illustration.

When ordering duplicate parts, always give the SYMBOL of the DRILL (which is cast on the side of the cylinder) and the NUMBER of the DRILL (which is stamped on the front of the cylinder, near the top), also NUMBER and NAME of part as per above list.



Ingersoll-Rand Drills on the Panama Canal at Empire, C. Z.   339 Ingersoll-Rand Drills are used on the Canal

GRIFFITH-STILLINGS PRESS
368 CONGRESS ST., BOSTON

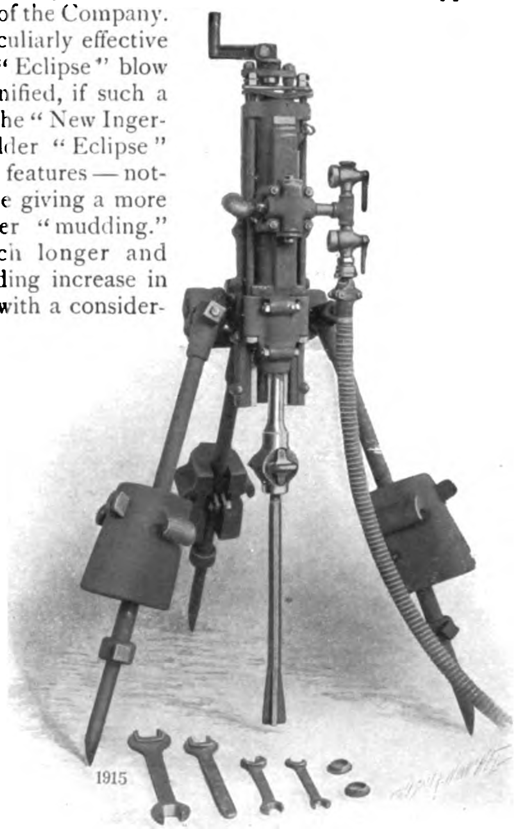
"NEW INGERSOLL" ROCK DRILLS

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 4006 September, 1909

THE "New Ingersoll" Drill is a combination of the best "Sergeant" features with the independent valve motion of the well-known Ingersoll "Eclipse" Drill, the resulting machine being one of extreme simplicity and of great efficiency and durability, but with a more limited field of application than the later types of the Company.

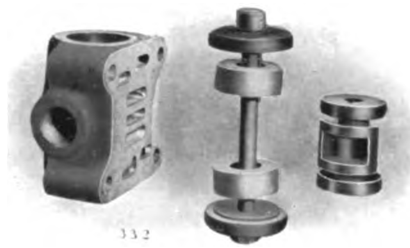
In this design the peculiarly effective quality of the well-known "Eclipse" blow is preserved or even magnified, if such a thing were possible. But the "New Ingersoll" differs from the older "Eclipse" Drill in several important features — notably in a lengthened stroke giving a more powerful blow and better "mudding." The piston is also much longer and heavier, with a corresponding increase in the force of the blow and with a considerable gain in the size of the wearing surfaces, the latter insuring durability, freedom from sticking, sustained tightness of working parts, and a full piston stroke. The rotation and other important parts are of the "Sergeant" design.



1915

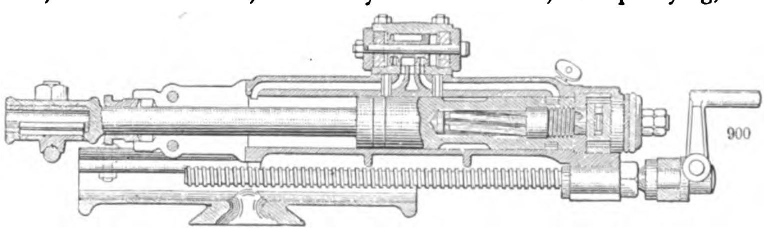
The "New Ingersoll" Drill has an independent air-thrown valve, the action of which is controlled by the movement of the piston. It has the variable stroke so necessary in working in caving, seamy, or broken ground; while its quick return "muds" the hole well. The blow is practically uncushioned and is of a particularly effective, penetrating character. With compressed air or with reasonably dry steam the "New Ingersoll" Drill will give excellent results in any ordinary material to which percussion drills are suited.

In selecting a drill for any duty, a clear distinction should be drawn between rocks which are merely hard, and those which are to be more properly described as tough — between a rock which will chip, and one which will crush or pulverize. There is a very wide field in which the "New Ingersoll" Drill will do more and better work than any other type. There are old customers, who have used the Company's machines throughout their development of the past thirty years, who still claim that the "New Ingersoll" is the best drill ever built. No doubt this is true in their particular case. There are other cases, however, in which the "Sergeant," "Little Giant," or "Arc Valve" Drills may with equal justice be said to be "the best." The question is fundamentally one of drilling conditions, but also very largely one of personal preference. There can be no doubt, however, that the "New Ingersoll" has in many of its sizes proven to be one of the best "all-around" drills on the market.



"New Ingersoll" Valve, Valve Guide Buffers, and Chest

This type of drill has always been a favorite in the "F," "G," "H," and "K" sizes, for heavy contract work, for quarrying, and for submarine excavation. It is certain that the "New Ingersoll" as a large drill has never been surpassed in economy, capacity, and endurance. But a construction which gives perfect satisfaction in large machines may not necessarily be the best one for smaller sizes. For instance, in the four large sizes just mentioned, generous bearing surfaces are possible throughout, and the rapid deterioration due to high speeds with small wearing surfaces is avoided. As representing later and more up-to-date constructions, the "Sergeant," "Little Giant," and "Arc Valve" models, in the "A," "B," "C," "D," and "E" sizes, are generally to be preferred. The "F" size is a particularly satisfactory machine in almost any of these models, and the choice of a type is largely a matter of rock characteristics, drilling conditions, and personal preference. The "New Ingersoll" Drill, therefore, continues to be built principally to meet the demands of old customers who will not have any other.

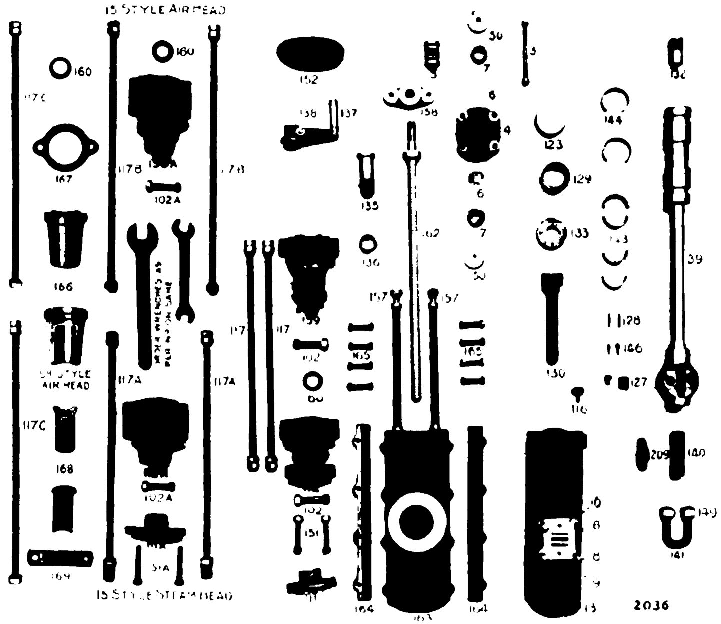


Longitudinal Section of "New Ingersoll" Drill

DESCRIPTIVE TABLE OF "NEW INGERSOLL" ROCK DRILLS (9 Type)

Symbol indicating size and type	B 9	C 9	D 9	E 9	F 9	G 9	H 9
DIMENSIONS:							
Diameter of cylinder . . . in.	$2\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{1}{8}$	$3\frac{1}{4}$	$3\frac{5}{8}$	$4\frac{1}{4}$	$5\frac{1}{2}$
Length of stroke . . . in.	6	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	7	9	8
Length of drill from end of crank to end of piston . . . in.	41	44	48	48	50	$58\frac{1}{2}$	60
Depth of hole drilled without change of bit . . . in.	20	24	24	24	24	30	30
Diameter of supply inlet (standard pipe) . . . in.	$\frac{3}{4}$	1	1	1	1	$1\frac{1}{2}$	$1\frac{1}{2}$
Approximate strokes per minute with 75 lbs pressure at drill	500	375	350	350	300	250	250
Depth of vertical hole each machine will drill easily, from 1 to . . . ft.	8	10	14	16	20	27	32
Diameter of holes drilled as desired, from . . . in.	**1 to $1\frac{1}{2}$**	**$1\frac{1}{4}$ to $2\frac{1}{4}$**	**$1\frac{1}{2}$ to $2\frac{1}{4}$**	**$1\frac{3}{4}$ to $2\frac{3}{4}$**	**$1\frac{3}{4}$ to 3**	**2 to 4**	**3 to 6**
Average work done per 10 hours in granite down holes, including time lost in setting drill and changing bits . . . ft.	70	70	70	75	75	75	75
Diameter of octagon steel used . . . in.	1 and $\frac{7}{8}$	$1\frac{1}{8}$ and 1	$1\frac{1}{4}$ and $1\frac{1}{8}$	$1\frac{1}{4}$ and $1\frac{1}{8}$	$1\frac{3}{8}$ and $1\frac{1}{4}$	$1\frac{5}{8}$ and $1\frac{1}{2}$	$1\frac{3}{4}$
Size of shanks (diameter and lengths) . . . in.	$\frac{7}{8}\times 5$	$1\times 5\frac{1}{2}$	$1\frac{1}{8}\times 6$	$1\frac{1}{8}\times 6$	$1\frac{1}{4}\times 6$	$1\frac{1}{2}\times 6\frac{1}{2}$	$1\frac{3}{4}\times 7$
Number of pieces in set of steels to drill holes in depths, as stated . . .	5	5	7	8	10	11	13
Best size of boiler to give plenty of steam at high pressure . .	8 H.P.	8 H. P.	8 H. P.	10 H. P.	10 H. P.	15 H. P.	18 H. P.
Best size of supply pipe to carry steam 100 to 200 ft. . . . in.	1	1	1	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{1}{2}$
APPROXIMATE WEIGHTS:							
Drill, unmounted, with wrenches and fittings, not boxed . . . lbs.	**170**	**245**	**275**	**280**	**405**	**760**	**930**
Drill, unmounted, with wrenches and fittings boxed . . . lbs.	210	290	325	330	460	990	1170
Tripod, without weights, not boxed . . . lbs	165	165	165	210	275	310	300
Tripod, without weights, boxed . . . lbs.	220	220	220	265	340	400	400
Holding down weights, not boxed . . . lbs.	270	285	285	330	375	375	375
Holding down weights, boxed . . . lbs.	295	315	315	360	420	420	420
Drill, tripod, weights, fittings, and wrenches, boxed lbs	**725**	**825**	**865**	**950**	**1220**	**1810**	**1990**
Drill and tripod, without weights and wrenches, not boxed lbs.	324	391	426	466	661	1045	1200
One set of steels, bundled . . . lbs.	66	101	229	292	536	1144	2080
One length of hose coupled, boxed . . . lbs.	105	105	105	105	105	120	120
SHIPPING MEASUREMENTS (OVER ALL):							
Box with unmounted drill and fittings . . . ft. in.	$3^{10}\ 1^{2}\ 0^{10}$	$4^{1}\ 1^{2}\ 0^{11}$	$4^{6}\ 1^{2}\ 0^{11}$	$4^{6}\ 1^{2}\ 0^{11}$	$4^{8}\ 1^{5}\ 1^{0}$	$5^{5}\ 2^{2}\ 1^{8}$	$5^{2}\ 2^{2}\ 1^{5}$
Box with tripod . . . ft. in.	$4^{5}\ 1^{6}\ 0^{10}$	$4^{5}\ 1^{6}\ 0^{10}$	$4^{5}\ 1^{6}\ 0^{10}$	$4^{5}\ 1^{6}\ 0^{10}$	$4^{6}\ 1^{8}\ 0^{10}$	$5^{1}\ 1^{10}\ 0^{11}$	$5^{1}\ 1^{10}\ 0^{11}$
Box with three weights . . . ft. in	$2^{7}\ 1^{0}\ 0^{10}$	$2^{7}\ 1^{0}\ 0^{10}$	$2^{8}\ 1^{2}\ 0^{10}$	$2^{8}\ 1^{2}\ 0^{10}$	$2^{10}\ 1^{4}\ 1^{0}$	$2^{10}\ 1^{4}\ 1^{0}$	$2^{10}\ 1^{4}\ 1^{0}$
Box with one length of hose . . . ft. in.	$2^{10}\ 2^{8}\ 0^{6}$	$2^{10}\ 2^{8}\ 0^{6}$	$2^{10}\ 2^{8}\ 0^{6}$	$2^{10}\ 2^{8}\ 0^{6}$	$2^{10}\ 2^{8}\ 0^{6}$	$2^{11}\ 2^{11}\ 0^{6}$	$2^{11}\ 2^{11}\ 0^{6}$
PRICES (F.O.B. EASTON OR NEW YORK) AND TELEGRAPH NAMES . . .	Vogelaceur	Vogelachia	Vogelacido	Vogelacier	Vogelacina	Vogelacion	Vogelacism
Drill unmounted, with wrenches and fittings, without tripod or column . . .	$225	$250	$275	$300	$320	$365	$700
Tripod and weights . . .	50	50	50	50	55	65	65
	Vogelacons	Vogelacrem	Vogelactum	Vogelacuta	Vogelad	Vogeladate	Vogeladeas
Drill complete, with tripod, weights and fittings . . .	**$275**	**$300**	**$325**	**$350**	**$375**	**$430**	**$765**

NOTE.—*Drill complete* includes drill, throttle, oiler, and wrenches, but does not include steels, hose, or blacksmith's tools. If mounted, tripod and weights or column and wrenches are included. **For full information and prices on Tripods, Columns, Hose, and Blacksmith's Tools, see Pamphlet No. 9003; and for Steels, see Pamphlet No. 9004.**



"NEW INGERSOLL" ROCK DRILLS

Sizes B9, C9, D9, E9, F9 — **DUPLICATE PART LIST**

Number	Name of Part
3	Valve Guide and Nut
4	Valve Chest Bare
5	Valve
6	Valve Washer
7	Valve Buffers
8	Steam Chest Studs and Nuts
9	Exhaust Port Bushing (front)
10	Exhaust Port Bushing (back)
13	Cylinder Bare
39	Piston Bare
50	Steam Chest Cover
102	Front Head Bolts and Nuts
102A	Front Head Bolts and Nuts for 15 Style Head
111	Split Gland
111A	Split Gland for 15 Style Head
112	Split Front Head for Steam
112A	Split Front Head for Steam, 15 Style
116	Thumb Screw
117	Through Bolts and Nuts
117A	Through Bolts and Nuts for 15 Style Steam Head
117B	Through Bolts and Nuts for 15 Style Air Head
123	Back Head
127	Rotating Pawl
128	Pawl Springs
129	Rotating Ratchet
130	Rifle Bar
132	Brass Nut
133	Rotation Washer
135	Feed Nut
136	Feed-nut Nut
*236	Feed-nut Lock Washer
137	Crank
138	Crank Bolt and Nut
*154	Crank Washer
140	Piston Bushing
141	U Bolt
143	Piston Ring
144	Piston Ring Spring
146	Pawl Plunger
149	U Bolt Nut
151	Gland Bolt and Nut
151A	Gland Bolt used with 15 Style Steam Head
152	Cushion Springs
157	Standard and Nut
*257	Standard Positive Lock Washer
158	Cross-head
159	Special Front Head (for air only)
159A	Special Front Head (for air only) 15 Style
160	Cup Leather
162	Feed Screw Square Thread
163	Shell without Caps
164	Square Guide Shell Cap
165	Shell Cap Bolt
209	Chuck Key

NOTES — Where the same drill parts are shown a number of times in cut, but in modified forms, letters A, B, etc., are added to the numbers to distinguish them. Either part can be used on the drill. The "15" style air and steam heads are the latest pattern and can be used on any old drill, providing new through bolts are ordered suitable for the head. When ordering duplicate parts always give the SYMBOL of the DRILL (which is cast on the side of the cylinder) and the NUMBER of the DRILL (which is stamped on the front of the cylinder, near the top), also number and name of the parts as per above list.

* Not shown in the illustration.

"LITTLE GIANT" ROCK DRILLS

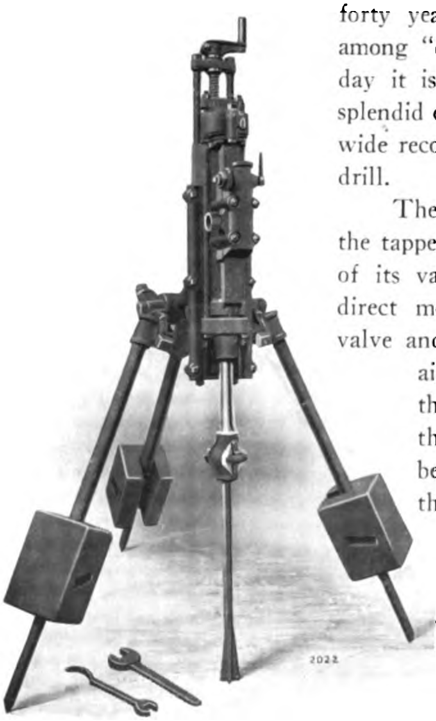
Ingersoll-Rand Company

11 Broadway, New York

Form No. 4003 **April, 1911**

THE persistence of a machine type in continuous use over a long period and in the face of keen competition of other types is conclusive proof of the merit of that particular type. This fact being recognized, the Ingersoll-Rand "Little Giant" Rock Drill must be said to have demonstrated its superiority beyond all question.

The tappet rock drill was among the earliest successful rock drill types. The "Little Giant" was the first really successful tappet drill, and continuous improvement and development have for nearly forty years kept it in the fore-front among "dependent valve" drills. To-day it is the finished refinement of a splendid original idea and enjoys world-wide recognition as the standard tappet drill.



The distinctive characteristic of the tappet drill is the positive character of its valve movement. There being direct mechanical connection between valve and drill piston, when steam or air is admitted to the cylinder the piston *must* move; and when the piston moves, the valve *must* be thrown, so that operation of the drill is a certainty. There is no hesitation, no incomplete travel, no fluttering of the valve, no uncertainty in the drill operation.

The tappet action is adaptable for use with any fluid, but when applied to a rock drill the best results are obtained from compressed air or dry "live" steam. This is to be expected; and under such conditions the "Little Giant" leaves nothing to be desired in its performances. It is with "wet" steam under rather low pressure, however, that the tappet action shows its peculiar superiority. In such cases a "steam thrown" valve is slow and uncertain in action and labors under a severe burden in disposing of condensed moisture. The "Little Giant," with its positive action and large, direct passages, meets these difficulties as no other drill can; and even with such operating handicaps shows a capacity far in advance of all competitive types.

"Little Giant" Valve Movement

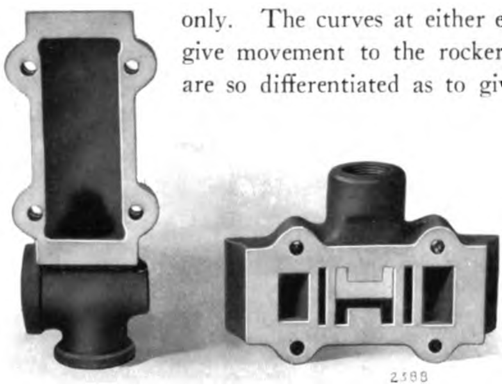
The "Little Giant" valve movement consists of three pieces: a valve, a rocker and a rocker pin. The rocker turns on the rocker pin and is so arranged that one or the other of its lower members is always in contact with the piston. Its upper member, ending in a globular shape, projects into the valve. When the piston moves, a curved surface slides under one of the rocker contacts, pushing the rocker upward and swinging the valve in the same direction as the piston is moving. On the reverse travel of the piston, this series of movements is exactly reversed. The throw of the valve covers and uncovers the supply and exhaust ports. Examination of the accompanying sectional view of the "Little Giant" Drill will reveal the following very important features:

"Little Giant" Valve, Rocker and Pin

The piston does not strike the rocker. It simply slides under the rocker contact gently, and pushes it up. The curve on this portion of the piston is carefully worked out so that the movement is the easiest possible and free from shock. The line of action is such that the effort, instead of being through or against the rocker pin,

is transmitted directly to the point of contact between rocker ball and valve. This eliminates all hammering and all tendency to bind or cut on the rocker pin. The latter is simply a free support for the rocker and not in any sense a thrust bearing opposed to a hammer blow. As the result of the latest improvement in the details of this design, all movements are easy and free, and there is the lightest possible duty on rocker, valve, pin and piston. The amount of energy taken from the blow to operate the valve movement is reduced to the practical limit.

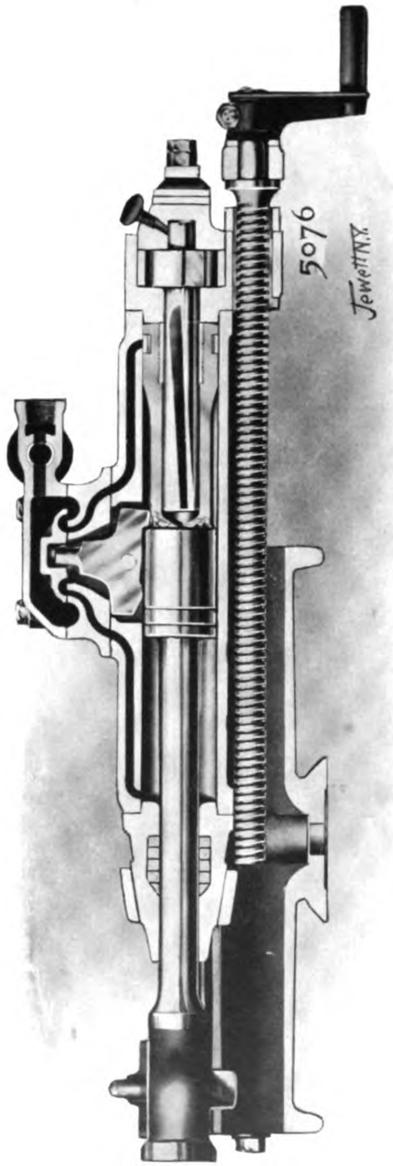
The rocker is symmetrical about the vertical axis through rocker pin and ball. This means that this part is reversible and cannot be put in place "wrong end to" by an inexperienced man. This permits also the use of a straight rocker pin instead of a taper. The holes in the cylinder for the rocker pin carries steel bushings which can be renewed when worn. These bushings work under exhaust pressure only. The curves at either end of the piston which give movement to the rocker are not identical, but are so differentiated as to give a correct distinction between the blow and the return. The arrangement of all parts is such that a clean, sharp cut-off is secured, which is a powerful factor in the economy of the "Little Giant."



"Little Giant" Valve Chest and Seat

The valve is held to its seat by live pressure, so that wear will only improve its fit. The rocker is in a chamber open to the drill exhaust. Pressure cannot enter the cylinder except through the ports, and there can be no leakage loss from this cause. If, when the piston rings or cylinder bore are worn, there should be a leakage of pressure past the piston, this live pressure passes out from the exhaust without in any way retarding the action of the piston or reducing the force of the blow. Full stroke and full power are thus maintained under long service.

The valve movement gives the correct variation in admission



Longitudinal Section of "Little Giant" Drill, Showing Plain Slide Valve

on the forward and return strokes, in this way economizing the steam or air. The back stroke is quick and positive, resulting in an unsurpassed "mudding" quality which adds to the cutting capacity of the "Little Giant."

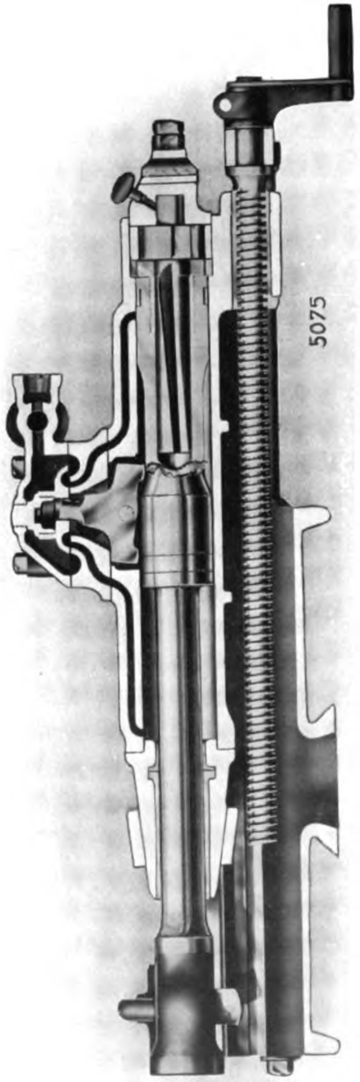
The arrangement of ports and the travel of the valve are such that there is a very slight cushion on the forward stroke, enough to add "life" and speed to the blow without noticeably reducing its force. On the return stroke there is an ample cushion of exhaust steam or air which assists in the forward stroke by its expansion.

A feature of the "Little Giant" worthy of special note is the free, direct passage offered to the exhaust. Owing to this detail, no drill works off condensed steam so readily. This, combined with the positive character of the valve movement, makes the "Little Giant" unequalled as a steam driven machine, whether the steam be "wet" or "dry." It goes without saying, however, that better results always follow the use of compressed air, with its "lively" action and with the improved lubrication due to the absence of water which may wash out the oil.

The Balanced Valve

A balanced slide valve is furnished on the "Little Giant" on special order when circumstances compel the use of steam or air at unusually high pressure. With this construction the strain on the valve mechanism is reduced, the action of the machine is made more free, and wear is reduced on piston, rocker, rocker pin, valve and valve seat. The details of this balanced valve are clearly shown in the accompanying sectional illustration.

The valve is accurately ground to parallel surface on its top and bottom. The opening for the rocker ball passes entirely through the valve. A bronze plug or ring holder is screwed and riveted into the valve chest, at such a depth that it just clears the top of the valve. Surrounding this plug, and turned to a working fit upon it, is a bronze ring, bearing on its inner face a suitable packing. This ring rests upon the upper surface of the valve. When pressure is admitted to the valve chest, it acts upon the upper edge of this ring to force it downward on the valve. The space between the plug and the ring is open to the atmosphere through the exhaust. The area of the valve which is covered by the ring is about 80 per



Longitudinal Section of "Little Giant" Drill, Showing Balanced Slide Valve

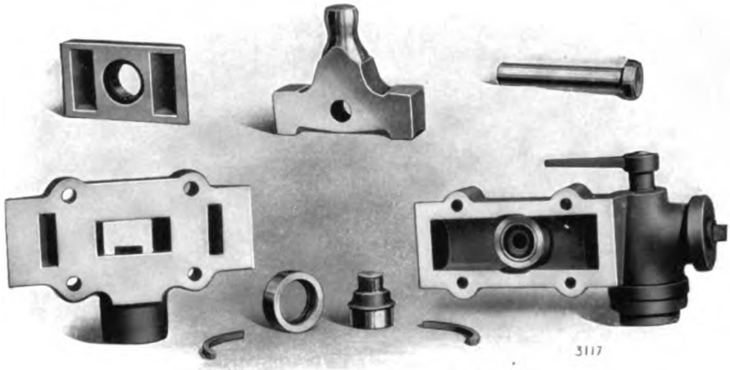
cent. of the valve area ordinarily exposed to working pressure. This valve movement is, therefore, 80 per cent. balanced and the friction between valve and seat is reduced in this proportion, easing the entire movement and reducing the wear on all parts involved.

This is essentially a special device, recommended only where such high pressures are used as, in an ordinary type of valve, would throw undue strain upon the drill and mechanism. For ordinary services it is not advised, since it calls for an added number of parts and joints, each of which (in a rock drill probably more than in any other machine) is an added element of complication.

Valve Chest and Valve Movement

The selection of the proper materials for the valve mechanism of the "Little Giant" has been the matter of years of study; the present practice represents a combination of the best materials at present available.

Ingersoll-Rand Drills at Work on the Site of the New Pennsylvania Railroad Terminal, New York



Parts of "Little Giant" Balanced Valve and Chest

The valve chest is a malleable casting with the throttle cast solid as a part of it. The latter is of the taper plug type, with automatic provision for wear which guards against leakage. The valve seat is a tough casting, with a shoulder which covers the rocker pin head, and prevents the latter from working out. The valve is a drop forging of high-carbon steel, machined to a perfect seat. The rocker also is a high-carbon steel, drop forging, machined and ground true. It is hardened at points of contact with the piston and valve. The ball shape at the top gives a rolling, rather than a sliding, contact with the valve. The rocker pin is of hardened high-carbon steel, locked in place as already described.

The Rotation

"Little Giant" Drills are regularly furnished with the standard "Rand" Rotation. Certain sizes, however, as designated in the table of specifications on page eleven, can be furnished on order with the "Sergeant Slip Rotation." Both of these devices are described in pamphlet 4001, which will be sent on request. The latter pamphlet also gives complete details as to materials used and methods of construction which are common to all Ingersoll-Rand drill types.

Lower Heads

Three types of lower head are offered on standard "Little Giant" Drills. As these are fully described in pamphlet 4001 it will be enough at this point to simply draw the distinctions between them.

The "Two-Bolt Split Lower Head" is adapted to either steam or air. The "Ring Lower Head" is especially intended for steam, having a special quality of steam packing. The "C and H Ring Lower Head" is a modification of the former type, designed for use with air, by substituting a cup leather for the steam packing.

Some Operating Features

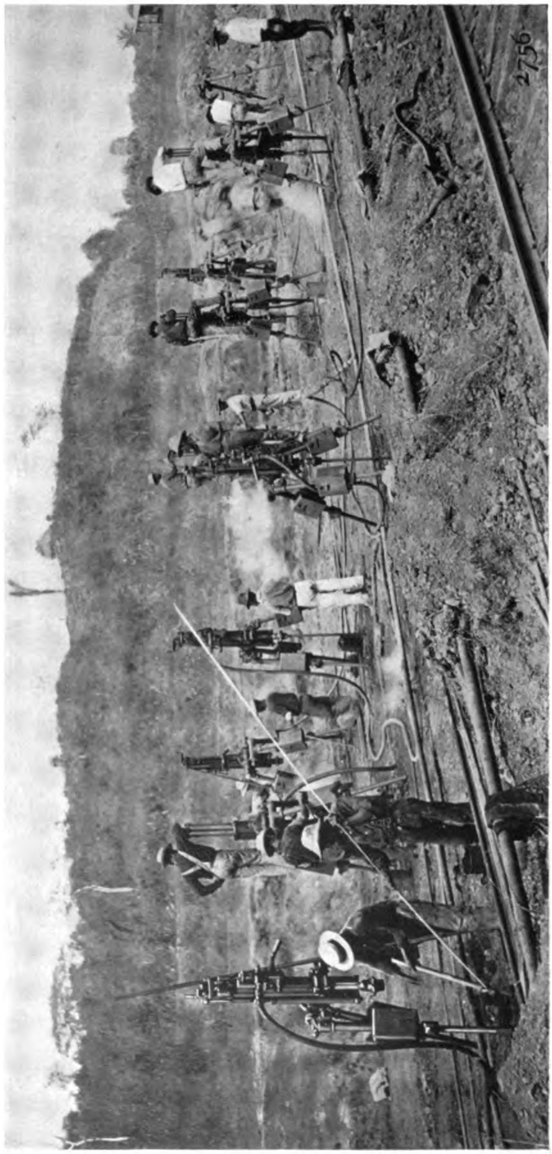
Examination of the sectional illustration shows how all working parts of the "Little Giant" Drill are directly exposed to the lubricant entering through the supply pipe. No drill is better lubricated than this, and the result is a remarkably free action, exceptionally long life, and fredom from repairs.

It has been said that the piston is slightly cushioned on the forward stroke. This is an advantage rather than otherwise in rock which is in any degree "springy" or elastic, where the best cutting effect cannot be secured by a dead, stunning blow. This cushion also gives the machine a "lively" action which is highly desirable.

Any tappet valve movement demands a piston travel sufficient to give the valve travel requisite to uncover the ports. This sets a limit to the stroke variation obtainable. But the design of the "Little Giant" is such as to give the necessary valve travel with a very short piston stroke. For this reason, this drill has a wider range of effective stroke than most tappet valve types. This feature secures full power and maximum cutting effect in hard, homogeneous materials free from seams, while still affording great pulling power in sheely, seamy rock or in a material with a tendency to cave and bind.

The Rand "Little Giant" Drill in its present model is the acme of simplicity and strength. Recent improvements have added to its power, economy and reliability under all conditions. It is today without doubt the most reliable and effective machine in the tappet valve class, and the most economical in operation and maintenance.

The table on page eleven gives detailed specifications as to sizes, weights and capacities of the standard "Little Giant" line. All orders should be based upon the information there given.



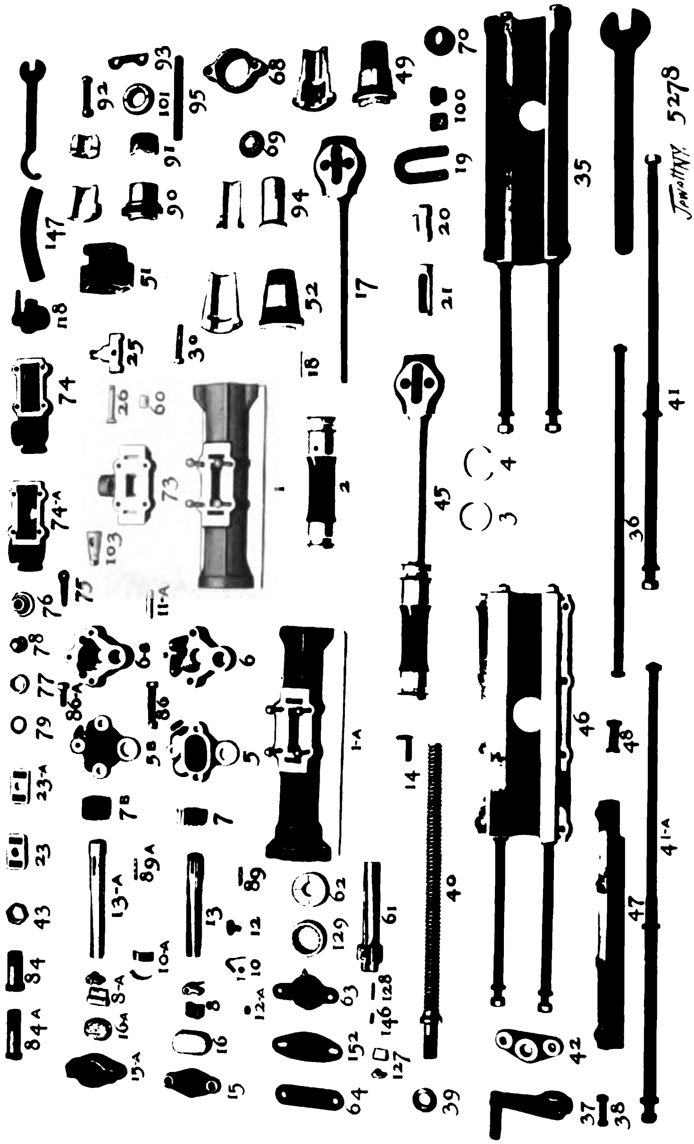
"Little Giant" Drills at Work on the Panama Canal

DESCRIPTIVE TABLE OF "LITTLE GIANT" DRILLS

Letter and Number Indicating Type	Kid Model 5	OD Model 5	1 Model 5	2A Model 5	2D Model 5	2B	3D & 3A Model 5	3B	3¼D Model 5	4D Model 5
DIMENSIONS:										
Diameter of Cylinder . . . in.	1⅞	2	2¼	2¾	2¾	2¾	3⅛	3⅛	3¼	3⅝
Length of Stroke . . . in.	3⅝	5¼	5⅜	6¼	6¼	6¼	6¾	6¾	6¾	7½
Length of drill from end of crank to end of chuck . . in.	33¾	38	39¾*	46½	46½*	45½	49*	48	55*	55†
Depth of hole drilled without change of bit . . . in.	10	15	18	18-24	18-24‡	18	24	24	24	30
Diameter of supply inlet (standard pipe) . . . in.	¾	¾	¾	¾	¾	¾	1	1	1	1
Approximate strokes per minute with 60 pounds pressure at drill . . .	700	550	500	450	450	450	400	400	400	325
Depth of vertical hole each machine will drill easily from 1 to . . . ft.	3-4	5	6	10	10	10	14	14	16	20
Diameter of holes drilled (at bottom) . . . in.	15/16	1	1 1/16	1½-1¾	1½-1¾	1½-1¾	1¾	1¾	1¾	2
Diameter of octagon steel used . . . in.	⅝	¾ or ⅞	¾ or ⅞	1 or 1⅛	1 or 1⅛	1 or 1⅛	1⅛ or 1¼	1⅛ or 1¼	1⅛ or 1¼	1⅜
Size of shanks (diameter and length) . . . in.	⅝ x 3	¾ x 5	¾ x 5	1 x 5½	1 x 5½	1 x 5½	1⅛ x 6	1⅛ x 6	1⅛ x 6	1⅜ x 6½
Number of pieces in set of steels to drill holes in depths as stated . . .	4	4	4	7 or 5	7 or 5	7 or 5	7	7	8	8
Best size of boiler to give plenty of steam at high pressure . . . hp.	3	5	6	8	8	8	8	8	10	12
Best size of supply pipe to carry steam or air 100 to 200 feet . . . in.	¾	¾	1	1¼	1¼	1¼	1½	1½	1½	2
APPROXIMATE WEIGHTS:										
Drill unmounted, with wrenches and fittings, not boxed . . . lbs.	**98**	**118**	**176**	**227**	**232**	**220**	**312 3A 321 3D**	**290**	**329**	**459**
Drill unmounted, with wrenches and fittings, boxed . . . lbs.	132	152	209	268	273	261	362 371	340	379	520
Drill, tripod, weights and wrenches, shipping weights . . . lbs.	328	348	527	769	754	762	920	889	928	1279
SHIPPING MEASUREMENTS (over all):										
Box with unmounted drill and fittings . . . ft. in.	$4^0\ 1^3\ 0^9$	$3^4\ 0^{11}\ 0^9$	$3^6\ 1^2\ 0^{11}$	$4^0\ 1^3\ 0^{11}$	$4^0\ 1^3\ 0^{11}$	$4^0\ 1^3\ 0^{11}$	$4^5\ 1^3\ 1^0$	$4^5\ 1^3\ 1^0$	$4^5\ 1^3\ 1^0$	$5^0\ 1^4\ 1^1$
Box with three weights . . . ft. in.										
Box with one length of hose . . . ft. in.	$3^0\ 3^0\ 10^0$	$3^0\ 3^0\ 10^0$	$3^0\ 3^0\ 10^0$	$3^0\ 3^0\ 10^0$	$3^0\ 3^0\ 10^0$	$3^0\ 3^0\ 10^0$	$3^0\ 3^0\ 10^0$	$3^0\ 3^0\ 10^0$	$3^0\ 3^0\ 10^0$	$3^0\ 3^0\ 10^0$
Prices (f. o. b. Painted Post or New York) and Telegraph Names: Drill unmounted with wrenches and fittings, without tripod or column . . .		**$170**	**$225**	**$275**	**$275**	**$275**	**$312.50**	**$312.50**	**$325**	**$362.50**
Tripod and weights . . .		$30	$30	$50	$50	$50	$50	$50	$50	$55
Drill complete with tripods, weights and fittings . . .										

*Add one inch to this length where Inserted Pawl Rotation is used. †Length with Inserted Pawl Rotation, 55⅜ inches. ‡When this drill is furnished with an eighteen-inch feed, its length is 44¾ inches.

NOTE. **Drill complete** includes drill, throttle, oiler and wrenches and does not include steels, hose or blacksmith's tools; if mounted, tripod or column and wrenches are included.



Duplicate Parts of Model 5 "Little Giant" Drills

DUPLICATE PART LIST OF MODEL 5 "LITTLE GIANT" DRILL

Taper Chest Complete (plain valve)
74 Taper Steam Chest Bare
103 Taper Throttle Plug
75 Taper Throttle Plug Handle
76 Taper Throttle Cap
23 Slide Valve (plain)
73 Valve Seat
25 Rocker
26 Rocker Pin (straight)

Taper Chest Complete (balanced valve)
74A Taper Steam Chest Bare
103 Taper Throttle Plug
75 Taper Throttle Plug Handle
76 Taper Throttle Cap
77 Balanced Valve Ring
78 Balanced Valve Ring Holder
79 Balanced Valve Ring Packing
23A Balanced Slide Valve
73 Valve Seat
25 Rocker
26 Rocker Pin (straight)

1 Cylinder Bare or Complete (includes parts 30 and 60)
30 Steam Chest Stud and Nut
60 Rocker Pin Bushing

1A Cylinder Bare or Complete for Sergeant Internal Rotation (includes parts 30 and 60.)
30 Steam Chest Stud and Nut
60 Rocker Pin Bushing

Rotation Complete (regular)
13 Rifle Bar
7 Ratchet
89 Ratchet Key
8 Pawl Complete (includes spring)
10 Pawl Spring

Rotation Complete (sergeant internal)
61 Rifle Bar
129 Rotating Ratchet
62 Rotation Washer
127 Rotation Pawl
146 Rotation Pawl Plunger
128 Rotation Pawl Spring
13A Rifle Bar

Rotation Complete (inserted pawl)
13A Rifle Bar
7B Ratchet
89A Ratchet Key
8A Pawl Bare
10A Pawl Spring

Piston Complete (solid piston and chuck)
45 Piston Bare (always includes Bushing unless otherwise specified)
21 Chuck Bushing
3 Piston Ring
4 Piston Ring Spring
19 Chuck Bolt (without nuts)
100 Chuck Bolt Nut
20 Chuck Key
14 Rotating Nut

Piston Complete (separate piston and chuck)
2 Piston Bare (without rotating nut)
17 Chuck Bare (always includes Bushing unless otherwise specified)
21 Chuck Bushing
18 Piston Key
3 Piston Ring
4 Piston Ring Spring
19 Chuck Bolt (without nuts)
100 Chuck Bolt Nut
20 Chuck Key
14 Rotating Nut

37 Feed Handle Complete
38 Feed Handle Bolt and Nut

Shell Complete (solid)
35 Shell Bare (includes standards and nuts)
41 Standard and Nut (regular and sergeant rotation)
41A Standard and Nut (inserted pawl rotation)
42 Crosshead

Shell Complete (adjustable)
46 Shell Bare (includes standards and nuts)
41 Standard and Nut (regular and sergeant rotations)
41A Standard and Nut (inserted pawl rotation)
47 Shell Slide
48 Shell Slide Bolt and Nut
42 Crosshead

Feed Screw Complete
40 Feed Screw
39 Feed Screw Washer
84 Feed Nut (regular and sergeant)
84A Feed Nut (inserted pawl)
43 Jam Nut

Back Head Complete (sergeant internal)
63 Back Head (includes oil plug)
12 Oil Plug

Upper Head Complete (regular)
5 Upper Head (includes oil plug)
12 Oil Plug
6 Ratchet Box (includes pawl studs)
11A Pawl Stud Plain
86 Ratchet Box Bolt and Nut

Upper Head Complete (inserted pawl)
5B Upper Head (includes oil plug)
12A Oil Plug
6B Ratchet Box Bare
86A Ratchet Box Stud and Nut

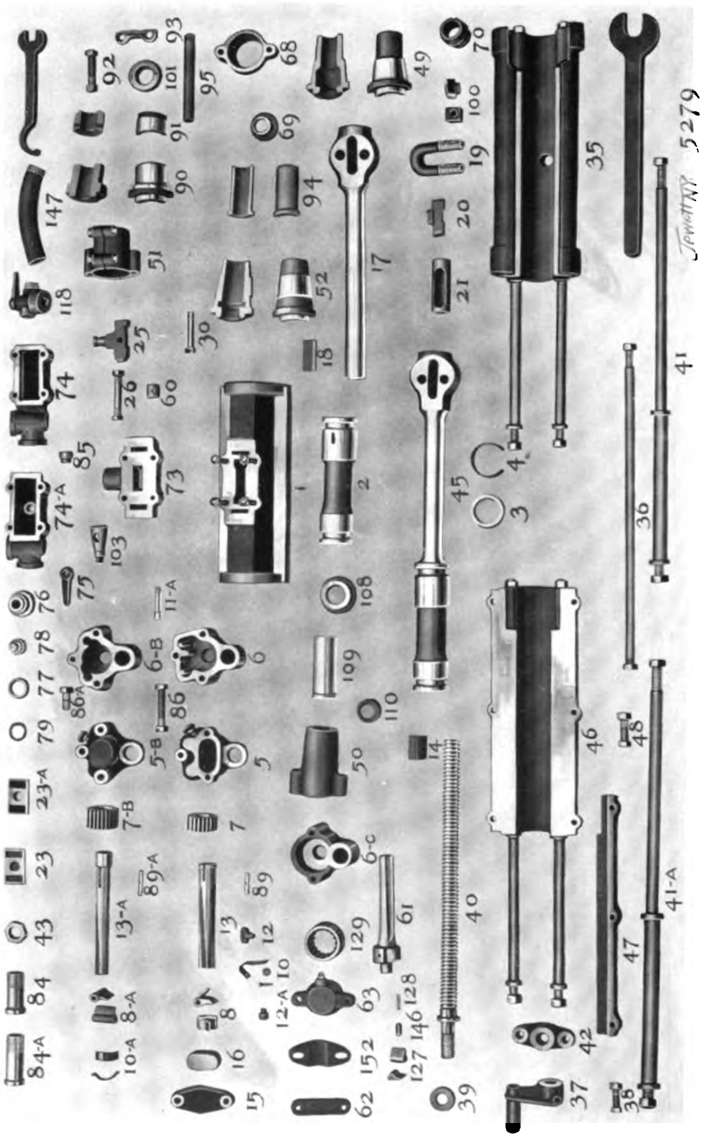
C and H Ring Lower Head Complete "Air"
52 C. and H. Lower Head Bare (two pieces)
94 C. and H. Lower Head Bushing (two pieces)
69 Leather Packing
68 C. and H. Lower Head Ring

Ring Lower Head Complete "Steam or Air"
49 Ring Lower Head Bare (two pieces)
68 Ring Lower Head Rink
70 Ring Lower Head Packing

Two-Bolt Split Lower Head Complete "Steam"

Two-Bolt Split Lower Head Complete "Air"
51 Steam or Air Head Bare (includes bolts and nuts)
92 Steam or Air Head Bolt and Nut
90 Steam or Air Head Bushing (two pieces)
91 Steam or Air Head Stuffer (two pieces)
93 Steam or Air Head Copper Filling Piece
95 Steam Head Packing
101 Air Head Split Ring
69 Air Head Split Ring Leather Packing

Miscellaneous
152 Cushion Spring (two pieces, for sergeant internal rotation)
64 Cushion Spring Strap (for sergeant internal rotation)
16 Cylinder Buffer (regular)
15 Cylinder Buffer Yoke (regular)
16A Cylinder Buffer (inserted pawl)
15A Cylinder Buffer Yoke (inserted pawl)
147 Exhaust Pipe
36 Cylinder Side Rod and Nut
118 Oiler



Duplicate Parts of B Type "Little Giant" Drills

Duplicate Part List of "B" Type "Little Giant" Drill

Taper Valve Chest Complete (plain valve)
74 Taper Chest Bare
103 Taper Throttle Plug
75 Taper Throttle Plug Handle
76 Taper Throttle Cap
23 Slide Valve
73 Valve Seat
25 Rocker
26 Rocker Pin and Nut (taper)

Taper Chest Complete (balanced valve)
74A Taper Chest Bare
103 Taper Throttle Plug
75 Taper Throttle Plug Handle
76 Taper Throttle Cap
77 Balanced Valve Ring
78 Balanced Valve Ring Holder
79 Balanced Valve Ring Packing
23A Balanced Slide Valve
25 Rocker
26 Rocker Pin and Nut (taper)

1 Cylinder Bare or Complete (includes steam chest studs and nuts)
30 Steam Chest Stud and Nut

Rotation Complete (sergeant external)
61 Rifle Bar
129 Rotation Ratchet
127 Rotation Pawl
146 Rotation Pawl Plunger
128 Rotation Pawl Plunger Spring

Rotation Complete (regular)
13 Rotating Bar
7 Ratchet
89 Ratchet Key
8 Pawl Complete (includes part 10)
10 Pawl Spring Complete (includes rivet and washer)

Rotation Complete (inserted pawl)
13A Rotating Bar
7B Ratchet
89A Ratchet Key
8A Pawl Bare
10A Pawl Spring

Piston Complete (solid piston and chuck)
45 Piston Bare (includes Bushing unless otherwise specified)
21 Chuck Bushing
3 Piston Ring
4 Piston Ring Spring
19 Chuck Bolt (without nuts)
100 Chuck Bolt Nut
20 Chuck Key
14 Rotating Nut

Piston Complete (separate piston and chuck)
2 Piston Bare (without rotating nut)
17 Chuck Bare (includes Bushing unless otherwise specified)
18 Piston Key
3 Piston Ring
4 Piston Ring Spring
19 Chuck Bolt (without nuts)
100 Chuck Bolt Nut
14 Rotating Nut

37 Feed Handle Complete
38 Feed Handle Bolt and Nut

Shell Complete (solid)
35 Shell Bare (includes standards and nuts)
41 Standard and Nut (regular)
41A Standard and Nut (inserted pawl)
42 Crosshead

Shell Complete (adjustable)
46 Shell Bare (includes standards and nuts)
41 Standard and Nut (regular)
41A Standard and Nut (inserted pawl)
47 Shell Slide
48 Shell Slide Bolt and Nut
42 Crosshead

Feed Screw Complete
40 Feed Screw
84 Feed Nut (regular)
84A Feed Nut (inserted pawl)
43 Jam Nut (regular and inserted pawl)

Back Head Complete (sergeant external)
63 Back Head (includes oil plug)
12 Oil Plug
6C Ratchet Box

Upper Head Complete (regular)
5 Upper Head (includes oil plug)
12 Oil Plug
6 Ratchet Box (includes pawl studs)
11 Pawl Stud Threaded
86 Ratchet Box Bolt and Nut

Upper Head Complete (inserted pawl)
5B Upper Head (includes oil plug)
12A Oil Plug
6B Ratchet Box Bare
86A Ratchet Box Stud and Nut

C and H Ring Lower Head Complete "Air"
52 Head Bare (two pieces)
94 Bushing (two pieces)
69 Leather Packing
68 Ring

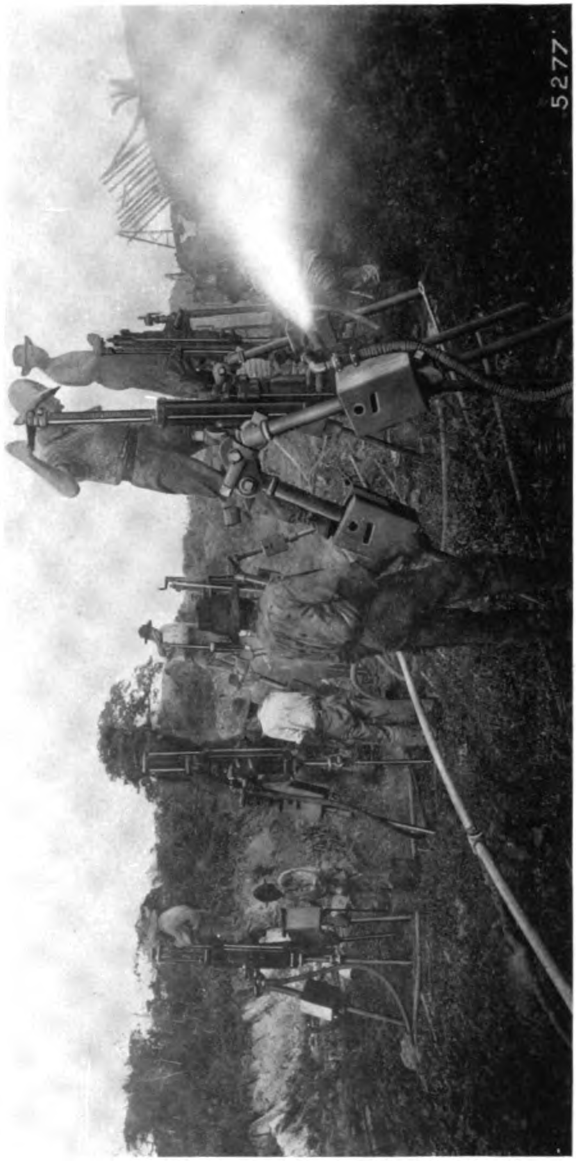
Ring Lower Head Complete "Steam or Air"
49 Head Bare (two pieces)
68 Ring
70 Packing

Two-Bolt Split Lower Head "Steam"

Two-Bolt Split Lower Head "Air"
51 Steam or Air Head Bare (includes bolts and nuts)
92 Steam or Air Head Bolt and Nut
90 Steam or Air Head Bushing (two pieces)
91 Steam or Air Head Stuffer (two pieces)
93 Steam or Air Head Copper Filling Piece
95 Steam Head Packing
101 Air Head Split Ring
69 Air Head Split Ring Leather Packing

C and H Lower Head Complete "Air"
50 Head Bare
108 Ring
109 Bushing
110 Leather Packing

Miscellaneous
152 Cushion Spring (two pieces)
62 Cushion Spring Strap
39 Feed Screw Washer
16 Cylinder Buffer
15 Cylinder Buffer Yoke
147 Exhaust Pipe
85 Chest Plug
36 Cylinder Side Rod and Nut



Ingersoll-Rand Drills on the Panama Canal

The MASON-HENRY Press
Syracuse and New York

ROCK DRILL MOUNTINGS, STEELS, HOSE AND ACCESSORIES

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 9003 January, 1911

THE rock drill as usually sold consists of the drill itself, with guide shell and feed screw, throttle, oiler and wrenches. But it does not include any mounting, or the necessary hose and steels. The various types of Ingersoll-Rand drills are described and listed in separate pamphlets. This pamphlet presents the standard line of Ingersoll-Rand drill mountings, air and steam hose, drill steels, and the other accessories usually entering into a complete rock drilling equipment.

While the efficiency and capacity of a rock drill plant depend primarily upon the drill itself, yet the quality of the accessories used has also an important bearing upon the performance of the outfit, the rate of progress, and the operating and up-keep cost. The severe service coming upon the drill itself is felt all along the line throughout the drill equipment; and it is therefore important that the drill accessories shall be well designed, well built and of a character to stand up under the most severe duty.

The line of Ingersoll-Rand rock drill equipment described and listed in this pamphlet has been created with this understanding; and it is fully comparable, in the essential qualities of satisfaction, with the Company's line of standard drills. It is a great mistake to expect good results from a high-class drill handicapped with a poor equipment. The Company's effort, therefore, has been to produce a consistent line of drills, mountings and accessories, of uniform superiority, and representing the very best value.

Rock Drill Mountings

The function of the mounting is to furnish a support to the drill which will be sufficiently rigid to maintain alignment of the steel with the hole. At the same time, it must be readily moved from hole to hole and must have a flexibility adapting it to all conditions of set-up.

Mounted on a Tripod

Rock drill practice has evolved four standard styles of mounting; the Tripod, for

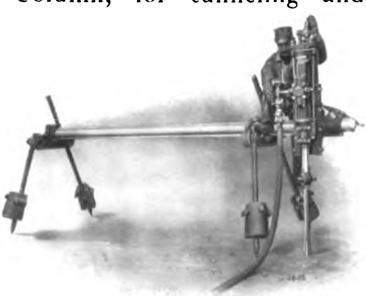
Mounted on a Column

open-cut work and to a limited extent for shaft sinking; the Column, for tunneling and

Mounted on a Gadder

shaft sinking; the Quarry Bar, for quarry work and some classes of contract excavation; and the Gadder, a device for special quarry duty.

The Company's several types of these mountings are illustrated and described in the next few pages.

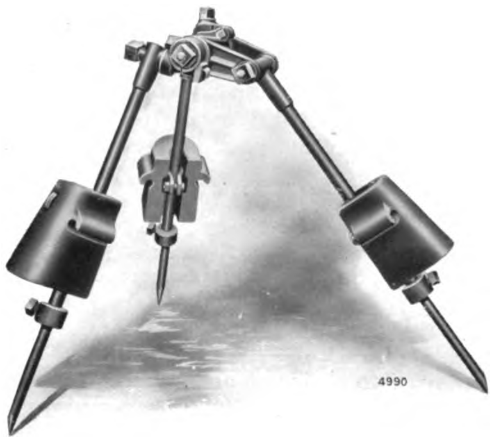


Mounted on a Quarry Bar

The "Sergeant 27" Tripod

The "27" Tripod is now the standard for all Ingersoll types of Ingersoll-Rand rock drills. It is an improvement upon the Sergeant "Universal" tripod, all the valuable features of which it retains. But it is heavier and stronger than the former type. All joints have cone surfaces, securing a powerful wedge effect under pressure of the adjusting bolts. The legs are telescopic and the weights adjustable.

The new "27" Tripod is regularly furnished with the "Sergeant" saddle for the modern drill types. But on special order it will be equipped with the "Ingersoll" saddle fitting the old "Eclipse" drill, or with a "Lewis Hole" saddle.

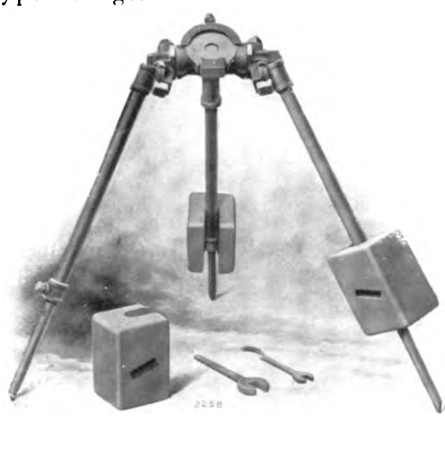


A Sergeant Tripod Complete

The "Rand Adjustable" Tripod

The "Rand Adjustable" Tripod is the standard for the Rand types of Ingersoll-Rand rock drills—"Little Giant" and "Slugger." The shell cones on Ingersoll and Rand drill types differ slightly so that they are not interchangeable with either type of tripod. The Rand tripod has every desirable feature and affords a mounting of great strength and solidity, together with a wide range of adjustability.

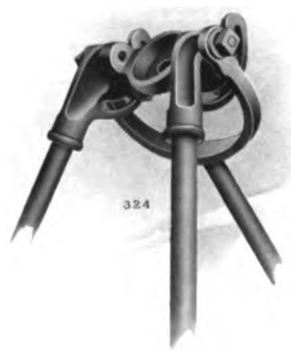
The "Rand" saddle is standard with this tripod but a "Lewis Hole" tripod for broaching will be furnished on order.



The "Rand Adjustable" Tripod

The "Quadrant" Tripod

Heavy, open-cut rock excavation, and other work calling for large, deep holes requiring the heaviest drills, demand a mounting of unusual strength; and since such holes are almost always vertical, or nearly so, no great range of adjustability is necessary in the mounting. The "Quadrant" Tripod is intended for such work. Its special feature is that the heavy drill need not be moved or tipped in changing steels, the quadrant dropping the machine back far enough to clear the hole.



A "Quadrant" Tripod

The "Ingersoll" Tripod

This is an old type of mounting carried only to meet the demands of old customers who prefer it, to keep their equipment uniform. While without the wide adjustability of the "27" Tripod, it affords satisfactory service in quarry or open-cut work where vertical or slightly inclined down holes predominate. It is furnished only with the "Ingersoll" saddle, for use with the "Eclipse" drill.

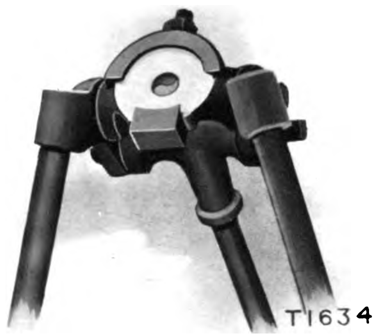
The "Sergeant" Saddle

The "Sergeant" Reversed Cone Saddle fits the "Sergeant," "Arc Valve" and "New Ingersoll" types of Ingersoll-Rand drills. It is extremely simple and very powerful. The drill can be released by simply slacking off the T-bolt. When cleaning holes or changing steels, the drill can be swung clear without losing alignment. The weight of the drill, and all stresses in drilling are borne by the rim of the saddle instead of by the T-bolt and jaw.

The "Sergeant" Saddle

The "Rand" Saddle

This also is a reversed cone saddle, but the angle of the cone fits the cone of the Rand types of Ingersoll-Rand drills. In general design, in its massive construction, in its powerful grip and in ease of manipulation, it is very similar to the "Sergeant" saddle. But in some minor details of construction it differs from the latter. It takes the standard "Little Giant" and "Slugger" drills.



The "Rand" Saddle

The "Lewis Hole" Saddle

This is a special device furnished where there are several holes to be drilled in line close together, but where the number does not justify using a quarry bar or gadder. When broaching is to be done, the wall between these closely-spaced, parallel holes is broken out by means of a broaching bit in the drill.

A "Lewis Hole" Tripod

In place of the usual saddle is a heavy cast frame with a slot in which a sliding saddle moves,fitting the shell cone. The travel of the saddle in the frame permits drilling three or four holes without moving the tripod. The saddles may be furnished to fit either Ingersoll or Rand types of drills.

The "Ingersoll" Saddle

This is retained only for old customers who prefer it, and for use with "Eclipse" drills and the larger sizes of the "New Ingersoll" drill. The shell and saddle are held together by a central bolt. Usually it is a part of the "Ingersoll" tripod, but may be furnished on the "Sergeant" tripod on order.

List of Stanpard "Sergeant," "Quadrant," and "Lewis Hole" Tripods for "Sergeant," "Arc Valve Tappet," "New Ingersoll," "Eclipse" and "Electric Air" Drills

Type	Size Letter (Symbol)	Used for Drills, Cylinder Diameter	Net Weight, Pounds			Price Complete	Telegraph Name	
			Tripod	Weights	Tripod Complete, and Weights		With Sergeant Saddle	With Ingersoll Saddle
Sergeant.......	A-27	2″	90	130	220	$35.00	Labrusque	Labsalben
Sergeant.......	A-86	2¼″	145	255	400	45.00	Labundum	Labung
Sergeant.......	B-27	2½″	160	255	415	55.00	Laburno	Labutacao
Sergeant.......	D-27	2¾″, 3″	174	336	510	60.00	Lacaussade	Lacayuno
Sergeant.......	E-27	3″, 3⅛″, 3¼″	324	336	560	65.00	Lacchetta	Lacchezzo
Sergeant.......	F-27	3½″, 3⅝″	296	370	666	75.00	Laccofilo	Laccos
Sergeant.......	G-27	4¼″, 4½″, 5″	315	370	685	85.00	Lacearan	Lacedaemon
Ingersoll........	A-1	2″, 2¼″	60	120	180	35.00	....	Lacerioso
Ingersoll.......	D-4	2¾″	160	285	445	60.00	....	Lacernatam
Ingersoll.......	F-3	3½″, 3⅝″	160	336	496	75.00	....	Lacertilia
Quadrant......	H-2	4¼″, 4½″, 5″	300	370	670	85.00	....	Lacertus
Lewis Hole.....	E-25-27	3″, 3⅛″, 3¼″	250	336	586	75.00	Lacesset	....
Lewis Hole.....	F-25-27	3½″, 3⅝″	320	370	690	85.00	Lacetani	....

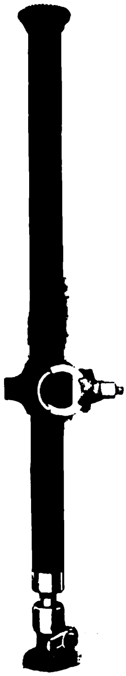
NOTE—The Sergeant Saddle is standard and is the form sent with all Sergeant Tripods unless otherwise specified. Sergeant Tripods are always supplied with saddle to mount the type of drill furnished.

List of Standard "Rand Adjustable" and "Lewis Hole" Tripods for "Little Giant" and "Slugger" Drills

Type	Size	Used for Drills, Cylinder Diameter	Net Weights, Pounds			Price Complete	Telegraph Name
			Tripod	Weights	Tripod Complete, with Weights		
Adjustable Tripod...........	No. 0	$1\frac{7}{8}''$ $2''$	80	102	182	$35.00	Laceraba
Adjustable Tripod...........	No 1*	$2\frac{1}{4}''$	90	210	300	45.00	Laceradora
Adjustable Tripod...........	No. 2	$2\frac{3}{4}''$	150	309	459	60.00	Lacerarian
Adjustable Tripod...........	No. 3	$3\frac{1}{8}''$, $3\frac{3}{16}''$, $3\frac{1}{4}''$	181	345	526	65.00	Lacerate
Adjustable Tripod...........	No. 4	$3\frac{5}{8}''$	333	399	732	75.00	Laceratore
Adjustable Tripod...........	No. 5	$3\frac{5}{8}''$, $4\frac{1}{2}''$	437	573	1010	85.00	Laceravate
Lewis Hole Tripod...........	No. 3	$3\frac{1}{8}''$, $3\frac{3}{16}''$, $3\frac{1}{4}''$	205	345	550	75.00	Lacewoman
Lewis Hole Tripod...........	No. 4	$3\frac{5}{8}''$	360	399	759	85.00	Lachanizo

*The "Little Giant" "1D Light" Drill with $2\frac{1}{4}$ inch Cylinder is mounted on a No. 0 Tripod Clamp.

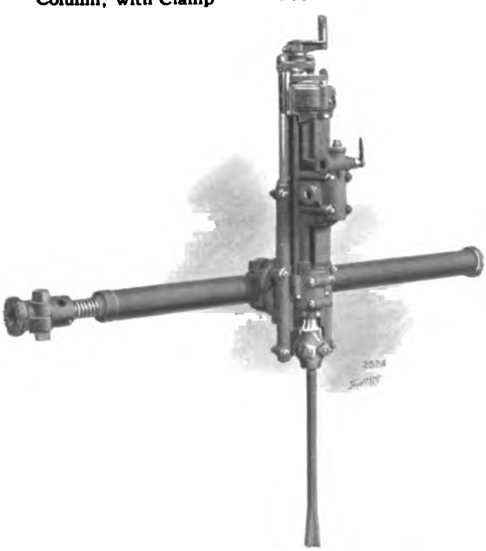
Columns and Arms



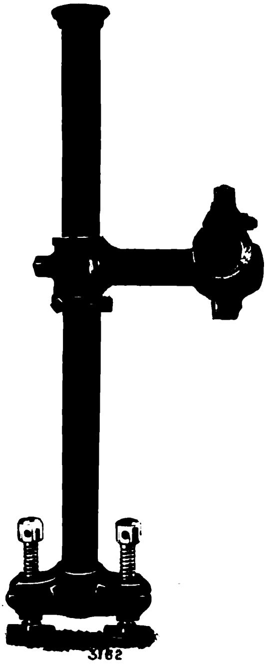
"Sergeant" Single Screw Column, with Clamp

The column mounting is furnished in two styles. The double screw column has two jack-screws at one end, with a rosette at the other. It is usually used in connection with a column arm, clamped upon the column and turning about it, and bearing a clamp and saddle carrying the drill. The single-screw column — sometimes called a shaft bar—has a rosette, but only one jack-screw, central with the column. With the double-screw column one or more clamps bearing drills may be mounted on the column arms, or on the column direct. A safety clamp on the column below the arm prevents the latter from falling when it is loosened to swing in any direction. With the single-screw column, however, the arm is frequently omitted, the clamp carrying

Special "Sergeant" Double Screw Broaching Column



"Rand" Single Screw Column



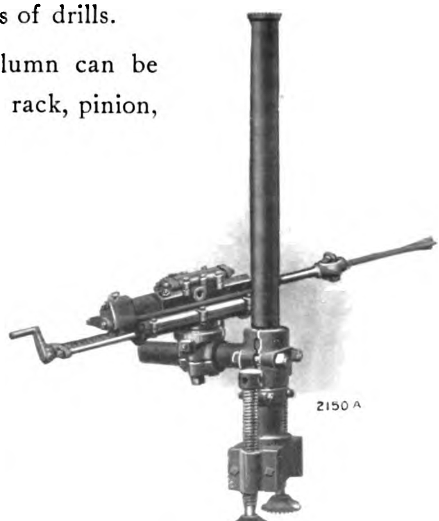
"Sergeant" Double Screw Column with Arm Clamp and Safety Clamp

the drill being mounted on the column direct, with the safety clamp below.

Ingersoll-Rand columns are offered in both Rand and Ingersoll types, differing only in minor construction details. Ingersoll columns carry clamps with either "Sergeant" or "Ingersoll" saddles, fitting only the Ingersoll types of Ingersoll-Rand drills. The "Sergeant" saddle, however, is standard and will be furnished unless otherwise ordered. Rand columns are fitted with "Rand" saddles for Rand types of drills.

Double Screw Swing Base Column

A special broaching column can be furnished on order, with a rack, pinion, spline and feed clamp, by which broaching may be done. In addition to the standard sizes of columns listed in the table, the Company is prepared to furnish extra long columns, and special combinations of columns, arms and clamps.



"Rand" Double Screw Column

List of Sergeant Single and Double Screw Columns for "Sergeant," "Arc Valve Tappet," "New Ingersoll," "Eclipse" and "Electric Air" Drills

Type	Outside Diameter	Min. Length Screws Run in, Feet	Suitable for Drills, Cylinder Diameter	Approximate Weights: Column Complete, Lbs.	Approximate Weights: Arm, Clamp and Safety Clamp, 5" Cone	Approximate Weights: Arm, Clamp and Safety Clamp, 7" Cone	Price Complete with Arm and Clamp.	Telegraph Names Complete
Double Screw Column.	3"	6'	2" to 2½"	140	60	95	$45.00	*Laadah
Double Screw Column.	3"	8'	2" to 2½"	156	60	95	45.00	*Laagstam
Double Screw Column.	3½"	6'	2¼", 2½"	227	95	110	55.00	*Laadband / Laadboom
Double Screw Column.	3½"	8'	2¼", 2½"	247	95	110	55.00	*Laakbaar / Laaksters
Double Screw Column.	4"	6'	2½", 2¾"	258	110	125	60.00	*Laadbus / Laadbussen
Double Screw Column.	4"	8'	2½", 2¾"	283	110	125	60.00	*Laakten / Laakziek
Double Screw Column.	4½"	6'	2¾" to 3¼"	344	...	165	70.00	Laadgat
Double Screw Column.	4½"	8'	2¾" to 3¼"	374	...	165	70.00	Laakzieker
Double Screw Column.	†5½"	6'	3½", 3⅝"	410	...	185	73.00	Laadgaten
Double Screw Column.	†5½"	8'	3½", 3⅝"	450	...	185	73.00	Laakzucht
Single Screw Column. .	3"	6'	2" to 2½"	95	30 (Clamp and Safety Clamp only)	... (Clamp and Safety Clamp only)	35.00	*Labbrone (Clamp and Safety Clamp only)
Single Screw Column. .	3"	8'	2" to 2½"	110	30	...	35.00	*Labefy
Single Screw Column. .	3½"	6'	2¼" to 2¾"	155	45	...	42.00	*Labbrotto
Single Screw Column. .	3½"	8'	2¼" to 2¾"	175	45	...	42.00	*Labefying
Single Screw Column. .	4"	6'	2½" to 2¾"	185	50	...	46.00	*Labeatium
Single Screw Column. .	4"	8'	2½" to 2¾"	210	50	...	46.00	*Labekuehle
Single Screw Column. .	4½"	6'	2¾" to 3¼"	230	...	85	55.00	Labefacti
Single Screw Column. .	4½"	8'	2¾" to 3¼"	260	...	85	55.00	Labellorum
Single Screw Column. .	5½"	6'	3½", 3⅝"	310	...	95	60.00	Labefactos
Single Screw Column. .	5½"	8'	3½", 3⅝"	350	...	95	60.00	Labendes

The length of column should always be specified as **closed**, i. e., **with the screws clear in.** Always allow from 10 to 14 inches for wood blocking.
Prices of Single Screw Columns complete do not include arm, which is not advised nor sent unless specified.
Longer or shorter columns than those listed will be furnished when ordered.
These weights and prices include Column Arms of the same diameter as the Column, which will be furnished unless otherwise specified except 5½-inch.
†Standard 5½-inch Column has 4½-inch Arm and 4½-inch Clamp; if wanted with 5½-inch Arm and 5½-inch Clamp, Price $77.00.
If arm and clamp are not wanted, it should be so specified. *With 5-inch cone clamp; all others 7-inch clamp.

List of "Rand" Single and Double Screw Columns for "Little Giant" and "Slugger" Drills

Type	Outside Diameter	Min. Length Screws Run in, Feet	Suitable for Drills, Cylinder Diameter	Approximate Weights: Column Pipe Complete, lbs.	Approximate Weights: Arm and Clamp lbs.	Approximate Weights: Total Weight lbs.	Price Complete with Arm and Clamp	Telegraph Names Complete
Double Screw Column....	2⅜"	6'	1⅞"	59	36	95	$40.00	Mauvaises
Double Screw Column....	2⅜"	8'	1⅞"	66	36	102	40.00	Mavortium
Double Screw Column....	2⅞"	6'	†2"	84	45	129	45.00	Mauveine
Double Screw Column....	2⅞"	8'	†2"	86	45	131	45.00	Mawkish
Double Screw Column....	4"	6'	2¼"	100	72	172	60.00	Mavolo
Double Screw Column....	4"	8'	2¼"	111	72	183	60.00	Mawkishly
Double Screw Column....	‡4½"	6'	2¼" to 3¼"	187	125	‡312	66.00	Mavolunt
Double Screw Column....	‡4½"	8'	2¼" to 3¼"	208	125	‡333	66.00	Mawmet
Double Screw Column....	4½"	6'	2¼" to 3¼"	195	134	329	70.00	Mavorcio
Double Screw Column....	4½"	8'	2¼" to 3¼"	216	134	350	70.00	Mawmetry
Double Screw Column....	5½"	6'	3⅝"	358	182	540	77.00	Mavortia
Double Screw Column....	5½"	8'	3⅝"	387	182	569	77.00	Mawworm
Single Screw Column.....	2⅜"	6'	1⅞"	45	17 (Clamp Only)	62	31.00 (Clamp only)	Maxima
Single Screw Column.....	2⅜"	8'	1⅞"	53	17	70	31.00	Maximize
Single Screw Column.....	2⅞"	6'	†2"	64	19	83	35.00	Maximiano
Single Screw Column.....	2⅞"	8'	†2"	76	19	95	35.00	Maximizing
Single Screw Column.....	4"	6'	2¼" to 3¼"	123	45	168	48.00	Maximianus
Single Screw Column.....	4"	8'	2¼" to 3¼"	140	45	186	48.00	Maximorum
Single Screw Column.....	4½"	6'	2¼" to 3¼"	140	54	193	55.00	Maximilian
Single Screw Column.....	4½"	8'	2¼" to 3¼"	160	54	214	55.00	Maxyer
Single Screw Column.....	5"	6'	3⅝"	182	74	256	60.00	Maximist
Single Screw Column.....	5"	8'	3⅝"	223	74	297	60.00	Mayada
Shaft Bar (one arm and	5"	8'	2¾" to 3¼"	182	188	370	86.00	Mayoresses
clamp for 1 drill).....	5"	8'	2¾" to 3¼"	182	191	373	90.00	**Mayorgado
Shaft Bar (arms and	5"	10'	2¾" to 3¼"	264	376	*951	169.50	Mayorista
clamps for 2 drills)...	5"	10'	2¾" to 3¼"	264	382	*957	177.50	**Mayormente

†"Little Giant" 1D Light Drill with 2¼-inch Cylinder is mounted on a 2⅞-inch Column.

*Includes 2 Arms, Center Legs and Weights. **With 4½-inch Intermediate Clamp, 4½-inch Arm and 4½-inch Arm Clamp. Other two with 4-inch.

‡With 4-inch Arm and 4-inch Clamp.

"Sergeant" Column Clamps, Column Arms and Safety Clamps

Column Clamps				Column Arms				Safety Clamps		
Size of Clamp	Size of Cone	Weight lbs	Telegraph Name	Size	Size Column to be used with	Weight lbs.	Telegraph Name	Size	Weight lbs.	Telegraph Name
3″	5″	25	Kursaelen	3″	3″	30	Kurszettel	3″	6	Kunibert
3½″	5″	40	Kurznasig	3½″	3½″	50	Kussenveer	3½″	7	Kunstjes
3½″	7″	55	Kurzohrig							
4″	5″	40	Kutschers	4″	4″	60	Kwanselen	4″	8	Kunstspel
4″	7″	55	Kutschlade							
4½″	7″	75	Kwelziek	4½″	4½″	80	Kwikbad	4½″	9	Kupfergare
5½″	7″	85	Kwilpillen	5½″	5½″	90	Kwistgoed	5½″	10	Kurbeere

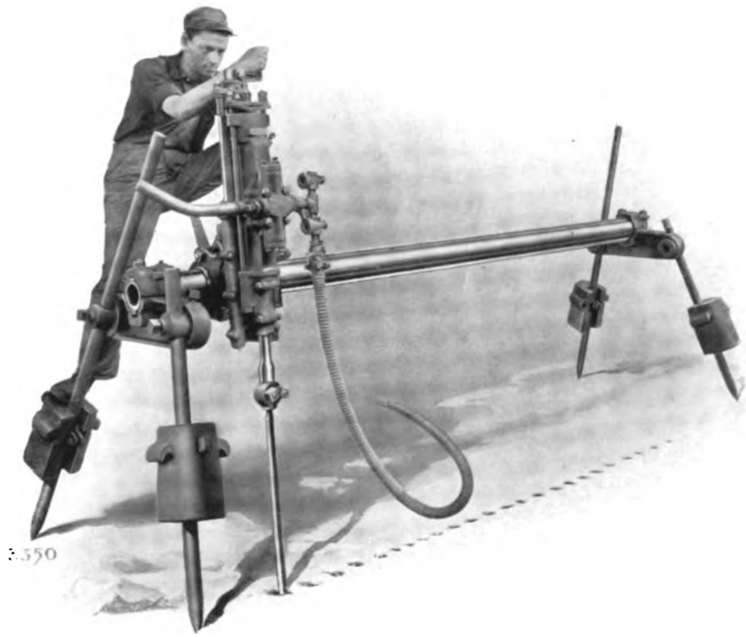
"Rand" Column Clamps, Column Arms and Safety Clamps

Column Clamps			Column Arms				Safety Clamps		
Size	Weight lbs.	Telegraph Name	Size	Column	Weight lbs.	Telegraph Name	Size	Weight lbs.	Telegraph Name
2⅜″	17	Marmolino	2⅜″	2⅜″	19	Marmoramus	2⅜″	3	Marmiton
2⅞″	19	Marmosets	2⅞″	2⅞″	26	Marmouser	2⅞″	3½	Marmorkalt
4″	27	Marotisme	4″	4″	45	Maroufle	4″	9	Maroquin
*4″	45	Marquisdom	4″	4½″	80	Marrers	4½″	11	Marquezita
4½″	54	Marsaune	4½″	4½″	80	Marsdrager	4½″	11	Marrugola
5″	74	Marspiter	5″	5½″	108	Marssteng	5½″	15	Marsjahres

* For use with 4½-inch column having 4-inch arm.

The Quarry Bar

The Quarry Bar is a standard type of drill mounting finding its largest application in stone quarrying. In materials having well-defined cleavage lines, this mounting is used in breaking out blocks by the plug-and-feather method and "lofting." In granite and similar materials, where the wedge system of breaking cannot be used, "broaching" is resorted to. This operation consists in



The Standard Ingersoll-Rand Quarry Bar

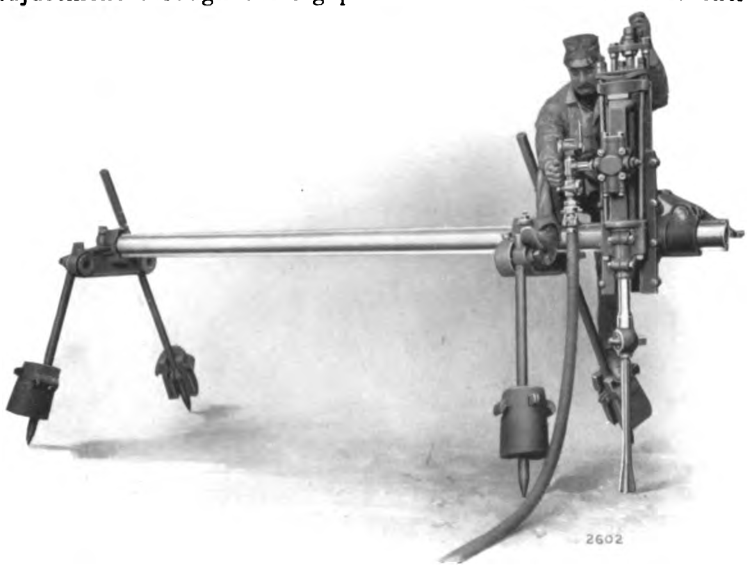
breaking out, by means of a special broaching bit, the thin walls between a row of closely spaced holes drilled along the plane on which the break must be made.

The quarry bar has also been used to great advantage in certain classes of contract work, as in sinking foundations in rock where it is necessary to maintain a smooth side wall.

In this class of work it is important that all the drill holes shall be in one plane, otherwise a clean break cannot be made. If a tripod is used for this, inequalities in the surface are almost sure to cause an irregular row of holes and a ragged break.

The special feature of the quarry bar is that all holes drilled from it are parallel and in the same plane. They may be spaced at any distance by simply moving the drill along the bar. For plug-and-feather work and "lofting" a row of holes is drilled to the desired depth and the break made by means of wedges. Sometimes it is necessary to drill these holes the full depth of the break desired. Sometimes the holes need be only comparatively shallow. In other cases deep and shallow holes alternately will do the work. Experience alone can determine the best method in any particular case. When "broaching" is to be done, a drill with a "release rotation" must be used, as the broaching bit must not rotate.

The Ingersoll-Rand Quarry Bar combines great strength and rigidity with a wide flexibility of adjustment for difficult set-ups. The leg posts turn on the end pieces and the legs have sliding adjustment through the leg posts. The bar is a tube of extra



The Ingersoll-Rand Quarry Bar, Illustrating the Use of the Drill at the End of Bar

heavy steel, with a rack-and-pinion for causing the longitudinal travel of the carriage and a spline to prevent the carriage turning on the bar. The saddle clamp carrying the drill, however, turns on the carriage, so that parallel holes can be drilled in any plane from horizontal to vertical.

When necessary to carry the line of holes close to a bench, the end piece and legs nearest the bench are moved in along the bar and the drill and carriage mounted beyond. In this way the row of holes can be carried to the extremity of the bar without loss of alignment.

The Ingersoll-Rand Quarry Bar is furnished complete with holding-down weights, carriage, saddle clamp, and the necessary wrenches. A drill, however, is not a part of the regular equipment. In ordering, the length of the quarry bar wanted should be clearly specified, together with the size and type of the drill which it is proposed to use. A general statement of the character of the work to be done will also be of material assistance to the Company in properly filling an order.

Ingersoll-Rand Quarry Bars

Size	Length of Bar over all	Length of Cut	Can be used with the following sizes of drills Cylinder diameter	Weight with weights but without drill	List Price	Telegraph Names	
						With 5-inch Clamp	With 7-inch Clamp
Light 3-inch	10′	8′ 4″	2 2¼ *2½	860 lbs.	$200.00	Lachziek	Laciez
Standard 4½-inch	12′	10′	*2¼ 2½ 2¾ 3 3¼ 3½ 3⅝	1460 lbs.	$250.00	Lacientis	Laciniada

Complete Quarry Bar includes Carriage, Weights and Wrenches, but no Drill.
*When a 2½-inch Drill is used on the 3-inch Light Quarry Bar, or a 2¼-inch Drill is used on the 4½-inch Standard Quarry Bar, a special saddle is necessary.

Shorter bars than those above listed will be furnished at the same price.

Price includes a complete bar with carriage, weights and wrenches, but no drill. For price with drill add to the above price of bar the list price of the drill to be used.

When a drill is wanted to go with a quarry bar, give telegraph name of bar followed by telegraph name of drill wanted, unmounted.

For sizes, prices and telegraph names of drills, see separate pamphlets, sent on request. For price of broaching steels for use with quarry bar, add one-third to the prices of standard rock drill steels listed on pages 19 to 24.

The Gadder

The Gadder is a special rock drill mounting designed for quarry work where a number of parallel holes are to be drilled in a plane, from nearly horizontal to vertical. Used in connection with the channeler, it is applied in "lofting," or drilling the horizontal under-cutting holes in material which has been channeled, to free it from the bed. It is also used in "plug-and-feather" work for breaking the large blocks channeled.

The machine is a heavy cast truck on wheels, with a hinged standard adjustable by a screw and hand-wheel from nearly horizontal to vertical. A saddle carrying a rock drill and shell slides in the gadder standard, being raised or lowered by means of a chain, sheave and drum. With the drill in proper position, a powerful wedge clamp grips the saddle in place. Anchor pins at the corners of the truck may be driven into the rock surface to maintain position.

Standard Ingersoll-Rand Gadder

A special drill shell and feed screw with a travel of three feet can be furnished on demand. The gadder uses drills of "C," "D," or "E" size (2¾, 3 or 3¼ inches) and drills of any model may be used. The "C-97" Gadder Drill is the machine usually used with the gadder. This is a modified "Sergeant" drill type, with 2¾-inch cylinder and a 36-inch feed. It is specially designed for very close work, having three supply connections.

The gadder equipment includes a truck with corner pins; one standard back screw, one long back screw, and one short back screw for frame; one 8-foot tie rod; full set of oilers and wrenches.

Price of gadder complete with drill, hose, steels, etc., is obtained by adding together the price of gadder here given, the price of drill (see separate pamphlets) and the price of accessories given later.

Equipment furnished with each Gadder Frame

One truck with corner pins.

One standard back screw, one long back screw and one extra short back screw for frame.

One full set of oilers.

One full set of wrenches.

One tie rod eight feet long.

Net price of Gadder Frame, $400.00 f. o. b. Factory.

Net price of "C-97" Gadder Drill, $165.00 f. o. b. Factory.

Net weight of Gadder Frame, without drill or fittings, 2,550 pounds.

Telegraph name of Gadder Frame, **Learnedly.**

Telegraph name of "C-97" Gadder Drill, **Leasehold.**

Telegraph name of Gadder Frame, complete, with "C-97" Drill, **Leasow.**

Price of the gadder, complete with drill, steels and hose, is obtained by adding the prices of the drill, steels and hose to that of the gadder frame.

Approximate shipping weight of gadder complete with drill:

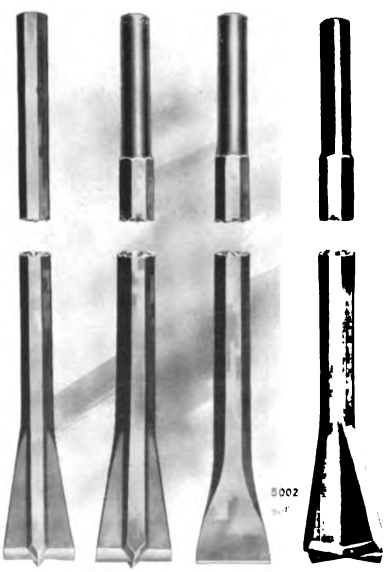
Class of drill:	"C"	"D"	"E"	
	3125	3140	3155	pounds.

Rock Drill Steels

Ingersoll-Rand rock drill steels are of the best quality to be had. The loss of gage on the bit varies with the material drilled; it is very rapid in hard and gritty rocks, and diminishes as the rock decreases in hardness. The difference in length between successive steels in a run is of course determined by the drill feed. Usually it is not more than two feet and may be much less; or it can be more when the conditions make it desirable. The change from one length to the next longer one presents a new, sharp cutting bit to the rock, and the rate of drilling is fairly uniform over the full depth of the hole.

A "set of steels" consists of a series of increasing lengths, the number depending upon the length of feed and the depth of the hole. The shortest length or "starter," will usually be about two feet. The diameter of bit diminishes as length increases, so that the gage of the starter will depend upon the depth of hole and the bottom diameter sought.

A set of steels is always understood to mean one piece of each length up to the desired maximum. At least two sets should be ordered with each drill, so that one may be sharpened while the other is in use. A greater number of sets than two is often an advantage, particularly in gritty rock.



Rock Drill Steels with and without Shanks, showing Standard Bits

In the tables of standard drill steels following, the lengths designated in heavy faced type are those which make up the set on orders for sets where no special number of lengths is designated. *In ordering drill steels, therefore, care must be taken to specify distinctly whether a set, duplicate set, or single steels are desired; also the maximum depth of hole which it is intended to drill.*

Standard "Ingersoll" Drill Steels for "Sergeant," "Arc Valve Tappet," "New Ingersoll," "Eclipse" and "Electric Air" Drills

A 24 — Shank 3/4 x 3 1/4 inches, Feed 12 inches — 2-inch "Sergeant" Drill

Length of each Steel not including Shank	Diameter of Standard Bit	Size of Steel	Weights: Each Steel Lbs.	Weights: Set Lbs.	Prices: Each Steel	Prices: Set	Telegraph Name of Set (See Note page 21)
1′	1 1/2″	3/4″	2 1/2	..	$1.30	....	Leastways
2′	1 3/8″	3/4″	4 1/2	7	1.54	$2.84	Leastwise
3′	1 1/4″	3/4″	7	14	1.84	4.68	Leathesie
4′	1 1/8″	3/4″	8	22	1.96	6.64	Leaveless
5′	1″	3/4″	9	31	2.16	8.80	Leaveneth

A 32, 35 — Shank 3/4 x 5 inches, Feed 15 inches — 2 1/4-inch "Arc Valve Tappet" "Baby"; 2-inch "Sergeant" "Light Mining"

Length of each Steel not including Shank	Diameter of Standard Bit	Size of Steel	Weights: Each Steel Lbs.	Weights: Set Lbs.	Prices: Each Steel	Prices: Set	Telegraph Name of Set
1′ 3″	1 1/2″	3/4″	3	..	$1.56	....	Leavening
2′ 6″	1 3/8″	3/4″	5	8	1.80	$3.36	Leavenous
3′ 9″	1 1/4″	3/4″	7	15	2.04	5.40	Lebadeam
5′	1 1/8″	3/4″	9	24	2.28	7.68	Lebaniego
6′ 3″	1 1/8″	3/4″	11	35	2.52	10.20	Lebban
7′ 6″	1 1/8″	3/4″	14	49	2.88	13.08	Lebbeus
8′ 9″	1 1/8″	3/4″	18	67	3.36	16.44	Lebbiger
10′	1 1/8″	3/4″	23	90	3.96	20.40	Lebbigheid

A 35 Special, 50, 86; B 104; 3 C—Electric Air — Shank 7/8 x 5 inches, Feed 15 inches — 2-inch "Sergeant" Special; 2 1/4-inch "Arc Valve Tappet"; 2 1/4-inch "Sergeant"

Length of each Steel not including Shank	Diameter of Standard Bit	Size of Steel	Weights: Each Steel Lbs.	Weights: Set Lbs.	Prices: Each Steel	Prices: Set	Telegraph Name of Set
1′ 3″	1 3/4″	7/8″	4	..	$1.68	....	Lebbrolina
2′ 6″	1 5/8″	7/8″	7	11	2.04	$3.72	Lebbroso
3′ 9″	1 1/2″	7/8″	9	20	2.28	6.00	Lebeche
5′	1 3/8″	7/8″	12	32	2.64	8.64	Lebedum
6′ 3″	1 1/4″	7/8″	14	46	2.88	11.52	Lebehoch
7′ 6″	1 1/4″	7/8″	16	62	3.12	14.64	Lebemann
8′ 9″	1 1/4″	7/8″	18	80	3.36	18.00	Lebemannes
10′	1 1/4″	7/8″	23	103	3.96	21.96	Lebemensch

B 2, 9, 24, 32; B 104 — Shank 7/8 x 5 inches, Feed 20 inches — 2 1/2-inch Ingersoll "Eclipse"; 2 1/2-inch "New Ingersoll"; 2 1/2-inch "Sergeant"; 2 1/2-inch "Arc Valve Tappet"

Length of each Steel not including Shank	Diameter of Standard Bit	Size of Steel	Weights: Each Steel Lbs.	Weights: Set Lbs.	Prices: Each Steel	Prices: Set	Telegraph Name of Set
1′ 8″	1 3/4″	1″	6	..	$1.92	....	Lebendig
3′ 4″	1 5/8″	1″	11	17	2.52	$4.44	Lebendiger
5′	1 1/2″	7/8″	13	30	2.76	7.20	Lebensader
6′ 8″	1 3/8″	7/8″	16	46	3.12	10.32	Lebensbahn
8′ 4″	1 1/4″	7/8″	20	66	3.60	13.92	Lebensbaum
10′	1 1/4″	7/8″	23	89	3.96	17.88	Lebensbild
11′ 8″	1 1/4″	7/8″	29	118	4.68	22.56	Lebensende

See NOTES, Page 21.

B[105] C 6 9 24 32

4E—Electric Air

Shank
1 x 5½ inches
Feed 24 inches

2¾-inch Ingersoll "Eclipse"
2¾-inch "New Ingersoll"
2¾-inch "Sergeant"
2¾-inch "Arc Valve Tappet"

Length Ea. Steel not including Shank	Diam. of Stand'd Bits	Size of Steel	Weights		Prices		Telegraph Name of Set (See Note, page 21)
			EachSt'l Lbs.	Set Lbs.	Each Steel	Set	
2′	**2¼″**	**1⅛″**	**10**	..	**$2.40**	....	**Lebensfroh**
4′	**2⅛″**	**1⅛″**	**17**	**27**	**3.24**	**$5.64**	**Lebensholz**
6′	**2″**	**1″**	**20**	**47**	**3.60**	**9.24**	**Lebensjahr**
8′	**1⅞″**	**1″**	**25**	**72**	**4.20**	**13.44**	**Lebensjoch**
10′	**1¾″**	**1″**	**29**	**101**	**4.68**	**18.12**	**Lebenskost**
12′	**1⅝″**	**1″**	**36**	**137**	**5.52**	**23.64**	**Lebenslauf**
14′	**1½″**	**1″**	**42**	**179**	**6.24**	**29.88**	**Lebenslust**
16′	1½″	1″	48	227	6.96	36.84	Lebensmai
18′	1½″	1″	60	287	8.86	45.70	Lebensmuth
20′	1½″	1″	70	357	10.06	55.76	Lebensoel
22′	1½″	1″	75	432	10.66	66.42	Lebenspfad
24′	1½″	1″	85	517	11.86	78.28	Lebensplan

D 9 24 32 E 3 9 32 33 44 52

5C—Electric Air

Shank
1⅛ x 6 inches
Feed 24 inches

3³⁄₁₆-inch Ingersoll "Eclipse"
3⅛ and 3¼-inch "New Ingersoll"
3 and 3¼-inch "Sergeant"
3⅛ and 3¼-inch "Arc Valve Tappet"

Length Ea. Steel not including Shank	Diam. of Stand'd Bits	Size of Steel	EachSt'l Lbs.	Set Lbs.	Each Steel	Set	Telegraph Name of Set
2′	**2½″**	**1¼″**	**12**	..	**$2.78**	....	**Lebensreiz**
4′	**2⅜″**	**1¼″**	**20**	**32**	**3.74**	**$6.52**	**Lebenssaft**
6′	**2¼″**	**1⅛″**	**24**	**56**	**4.22**	**10.74**	**Lebenssatz**
8′	**2⅛″**	**1⅛″**	**31**	**87**	**5.06**	**15.80**	**Lebenstag**
10′	**2″**	**1⅛″**	**40**	**127**	**6.14**	**21.94**	**Lebenswah**
12′	**1⅞″**	**1⅛″**	**49**	**176**	**7.22**	**29.16**	**Lebensweg**
14′	**1¾″**	**1⅛″**	**53**	**229**	**7.70**	**36.86**	**Lebenswelt**
16′	**1⅝″**	**1⅛″**	**63**	**292**	**8.90**	**45.76**	**Lebenszeit**
18′	1⅝″	1⅛″	76	368	10.78	56.54	Lebensziel
20′	1⅝″	1⅛″	82	450	11.50	68.04	Lebenvoll
22′	1⅝″	1⅛″	88	538	12.22	80.26	Leberader
24′	1⅝″	1⅛″	95	633	13.06	93.32	Leberaloe
26′	1⅝″	1⅛″	105	738	14.26	107.58	Leberblume
28′	1⅝″	1⅛″	117	855	15.70	123.28	Leberbraun
30′	1⅝″	1⅛″	130	985	16.26	139.54	Leberbruch

F 3 9 24 32 94 FA

Shank
1¼ x 6 inches
Feed 24 inches

3½-inch Ingersoll "Eclipse"
3⅝-inch "New Ingersoll"
3⅝ and 3½-inch "Sergeant"
3⅝-inch "Arc Valve Tappet"

Length Ea. Steel not including Shank	Diam. of Stand'd Bits	Size of Steel	EachSt'l Lbs.	Set Lbs.	Each Steel	Set	Telegraph Name of Set
2′	**2⅝″**	**1⅜″**	**14**	...	**$3.02**	....	**Leberfisch**
4′	**2½″**	**1⅜″**	**24**	**38**	**4.22**	**$7.24**	**Leberfleck**
6′	**2⅜″**	**1¼″**	**30**	**68**	**4.94**	**12.18**	**Leberfuchs**
8′	**2¼″**	**1¼″**	**38**	**106**	**5.90**	**18.08**	**Lebergalle**
10′	**2⅛″**	**1¼″**	**49**	**155**	**7.22**	**25.30**	**Lebergang**
12′	**2″**	**1¼″**	**57**	**212**	**8.18**	**33.48**	**Leberklee**
14′	**1⅞″**	**1¼″**	**68**	**280**	**9.50**	**42.98**	**Leberkolik**
16′	**1¾″**	**1¼″**	**75**	**355**	**10.34**	**53.32**	**Leberkraut**
18′	1¾″	1¼″	85	440	11.86	65.18	Lebermoose
20′	1¾″	1¼″	96	536	13.18	78.36	Lebernetz
22′	1¾″	1¼″	105	641	14.26	92.62	Leberrinne
24′	1¾″	1¼″	115	756	15.46	108.08	Leberspatz
26′	1¾″	1¼″	125	881	16.66	124.74	Leberstein
28′	1¾″	1¼″	140	1021	18.46	143.20	Lebersucht
30′	1¾″	1¼″	155	1176	20.26	163.46	Leberthran
32′	1¾″	1¼″	165	1341	21.46	184.92	Leberwurm

G 2, 3, 9, A1, A2 — A3 H 2, 3, A1, A3	Shank 1½ x 6½ inches Feed 30 inches	4¼, 4½ and 5-inch Ingersoll "Eclipse" 4¼-inch "New Ingersoll"

Length of each Steel not including Shank	Diameter of Standard Bit	Size of Steel	Weights		Prices		Telegraph Name of Set (See Note Below)
			Each Steel Lbs.	Set Lbs.	Each Steel	Set	
2′	**3″**	**1⅝″**	**21**	**....**	**$5.52**	**.....**	**Leberwurst**
4′ 6″	**2⅞″**	**1⅝″**	**39**	**60**	**7.68**	**$13.20**	**Leberzelle**
7′	**2¾″**	**1½″**	**49**	**109**	**8.88**	**22.08**	**Lebete**
9′ 6″	**2⅝″**	**1½″**	**67**	**176**	**11.04**	**33.12**	**Lebewohl**
12′	**2½″**	**1½″**	**84**	**260**	**13.08**	**46.20**	**Lebhaft**
14′ 6″	**2⅜″**	**1½″**	**100**	**360**	**16.00**	**62.20**	**Lebhaftest**
17′	**2¼″**	**1½″**	**120**	**480**	**18.40**	**80.60**	**Lebhonig**
19′ 6″	**2⅛″**	**1½″**	**136**	**616**	**20.32**	**100.92**	**Lebias**
22′	**2″**	**1½″**	**158**	**774**	**23.96**	**124.88**	**Lebidon**
24′ 6″	2″	1½″	176	950	26.12	151.00	Lebimus
27′	2″	1½″	194	1144	28.28	179.28	Lebkuchen
29′ 6″	2″	1½″	212	1356	30.44	209.72	Leblos
32′	2″	1½″	230	1586	32.60	242.32	Lebloser
34′ 6″	2″	1½″	248	1834	34.76	277.08	Lebmaag

H 9, 17, 61	Shank 1¾ x 7 inches Feed 30 inches	5½-inch "New Ingersoll"

Length of each Steel not including Shank	Diameter of Standard Bit	Size of Steel	Each Steel Lbs.	Set Lbs.	Each Steel	Set	Telegraph Name of Set
2′	**3¼″**	**1¾″**	**27**	**....**	**$8.36**	**......**	**Lebmagen**
4′ 6″	**3⅛″**	**1¾″**	**48**	**75**	**10.88**	**$19.24**	**Lebracho**
7′	**3″**	**1¾″**	**70**	**145**	**13.52**	**32.76**	**Lebrada**
9′ 6″	**2⅞″**	**1¾″**	**90**	**235**	**15.92**	**48.68**	**Lebrel**
12′	**2¾″**	**1¾″**	**114**	**349**	**18.80**	**67.48**	**Lebresinha**
14′ 6″	**2⅝″**	**1¾″**	**136**	**485**	**24.32**	**91.80**	**Lebrillada**
17′	**2½″**	**1¾″**	**160**	**645**	**27.20**	**119.00**	**Lebrillo**
19′ 6″	**2⅜″**	**1¾″**	**180**	**825**	**29.60**	**148.60**	**Lebrinha**
22′	**2¼″**	**1¾″**	**204**	**1029**	**35.14**	**183.74**	**Lebrones**
24′ 6″	2¼″	1¾″	232	1261	38.50	222.24	Lebruno
27′	2¼″	1¾″	253	1514	41.08	263.32	Lebtag
29′ 6″	2¼″	1¾″	264	1778	42.34	305.66	Lebwaare
32′	2¼″	1¾″	302	2080	46.90	352.56	Lebynthos
34′ 6″	2¼″	1¾″	326	2406	52.44	405.00	Lebzeiten
37′	2¼″	1¾″	350	2756	55.32	460.32	Lecanactis
39′ 6″	2¼″	1¾″	374	3130	58.20	518.52	Lecananto
42′	2¼″	1¾″	398	3528	61.08	579.60	Lecanora

NOTES—A SET CONSISTS OF ONE STEEL OF EACH LENGTH. Each code word, as given in the table, refers to ONE FULL SET up to the length opposite that word.

In ordering drill steels be sure to specify whether X, +, Z, or sandstone bits are wanted. Cross (+) bits will be furnished unless otherwise ordered.

Steels in "C" sizes (see top of page 20) are furnished on special order for "D" drills when bushing is changed to correspond.

Steels listed in **heavy type** are STANDARD SIZES and are known as stock steels, and will be shipped unless length is specified; all other lengths, given in LIGHT TYPE, are SPECIAL and are made to order. When a set of steels longer than given in heavy type in above list is ordered, the bit of the longest special steel is made the diameter as given in the table for longest stock steel, and the bit diameters on all shorter steels are increased ⅛-inch for each steel to maintain the same ratio of diameters. All stock steels having the same size shank and length of run are the same, regardless of the drill for which used. When ordering steels it is better to order two or more sets, so blacksmith can be sharpening one set while other is in use.

For prices of special broaching steels and bits for broach channeling add one-third to price of regular drill steels of same size and length of shank.

Standard "Rand" Drill Steels for "Little Giant" and "Slugger" Drills

For 2-inch "Little Giant" Drills

Shank ¾ x 3¼ inches
¾-inch Steel
Feed, 12 inches

Length of each Steel not including Shank	Diameter of Standard Bit	Weights: Each Steel Lbs.	Weights: Set Lbs.	Prices: Each Steel	Prices: Set	Telegraph Name of Set (See Note page 23)
1′	1¼″	2.25	.....	$1.30	....	Meriggi
2′	1 3/16″	3.75	6.0	1.54	$2.84	Meriggiato
3′	1⅛″	5.75	11.75	1.84	4.68	Meriggiavi
4′	1 1/16″	7.0	18.75	1.96	6.64	Meriggione

For 2-inch "Little Giant" Drills

Shank ¾ x 5 inches
¾-inch Steel*
Feed, 15 inches

Length of each Steel not including Shank	Diameter of Standard Bit	Weights: Each Steel Lbs.	Weights: Set Lbs.	Prices: Each Steel	Prices: Set	Telegraph Name of Set (See Note page 23)
1′ 3″	1⅜″	2.8	.....	$1.56	....	Merimnete
2′ 6″	1 5/16″	4.8	7.6	1.80	$3.36	Merindad
3′ 9″	1¼″	6.8	14.4	2.04	5.40	Meringue
5′	1 3/16″	8.8	23.2	2.28	7.68	Meriniden
6′ 3″	1⅛″	10.8	34.0	2.52	10.20	Meriologia

For 2¼-inch "Little Giant" Drills

Shank ¾ x 5 inches
¾-inch Steel*
Feed, 15 inches

Length of each Steel not including Shank	Diameter of Standard Bit	Weights: Each Steel Lbs.	Weights: Set Lbs.	Prices: Each Steel	Prices: Set	Telegraph Name of Set (See Note page 23)
1′ 3″	1½″	3	..	$1.68	....	Meriphe
2′ 6″	1 7/16″	5	8	2.04	$3.72	Merismatic
3′ 9″	1⅜″	7	15	2.28	6.00	Merismorum
5′	1 5/16″	9	24	2.64	8.64	Merismos
6′ 3″	1¼″	11	35	2.88	11.52	Meritabo
7′ 6″	1 3/16″	13	48	3.12	14.64	Meritabunt

For 2¼-inch "Little Giant" Drills

Shank ¾ x 5 inches
¾-inch Steel
Feed, 18 inches

Length of each Steel not including Shank	Diameter of Standard Bit	Weights: Each Steel Lbs.	Weights: Set Lbs.	Prices: Each Steel	Prices: Set	Telegraph Name of Set (See Note page 23)
1′ 6″	1½″	3.4	.....	$1.80	....	Meritames
3′	1 7/16″	5.8	9.2	2.04	$3.84	Meritant
4′ 6″	1⅜″	8.2	17.4	2.28	6.12	Meritantem
6′	1 5/16″	10.6	28.0	2.52	8.64	Meritavero
7′ 6″	1¼″	13.0	41.0	2.76	11.40	Meritedly
9′	1 3/16″	15.4	56.4	3.00	14.40	Merithal

*For ⅞-inch steel, add 40 per cent. to weights given for ¾-inch.
See NOTES, Page 23.

For $2\frac{3}{4}$-inch "Little Giant" Drills For $2\frac{3}{4}$-inch "Slugger" Drills	Shank 1 x $5\frac{1}{2}$ inches 1-inch Steel Feed, 18 inches

Length of each Steel not including Shank	Diameter of Standard Bit	Weights		Prices		Telegraph Name of Set (See Note Below)
		Each Steel Lbs.	Set Lbs.	Each Steel	Set	
1′ 6″	**$2\frac{1}{4}$″**	**7.0**	.....	**$2.30**	....	**Meriting**
3′	**$2\frac{1}{8}$″**	**11.5**	**18.5**	**2.75**	**$5.05**	**Meritoire**
4′ 6″	**2″**	**16.0**	**34.5**	**3.20**	**8.25**	**Meritorios**
6′	**$1\frac{7}{8}$″**	**20.5**	**55.0**	**3.65**	**11.90**	**Meritory**
7′ 6″	**$1\frac{3}{4}$″**	**25.0**	**80.0**	**4.10**	**16.00**	**Merkbar**
9′	$1\frac{5}{8}$″	29.0	109.0	4.50	20.50	Merkbarer
10′ 6″	$1\frac{1}{2}$″	33.0	142.0	4.90	25.40	Merkdoek
12′	$1\frac{3}{8}$″	37.0	179.0	5.30	30.70	Merkelijk

For $2\frac{3}{4}$-inch "Little Giant" Drills For $2\frac{3}{4}$-inch "Slugger" Drills	Shank 1 x $5\frac{1}{2}$ inches 1-inch Steel Feed, 24 inches

2′	**$2\frac{1}{4}$″**	**9**	...	**$2.40**	....	**Merkkatoen**
4′	**$2\frac{1}{8}$″**	**15**	**24**	**3.24**	**$5.64**	**Merklap**
6′	**2″**	**21**	**45**	**3.60**	**9.24**	**Merklappen**
8′	**$1\frac{7}{8}$″**	**27**	**72**	**4.20**	**13.44**	**Merkletter**
10′	$1\frac{3}{4}$″	33	105	4.68	18.12	Merklich
12′	$1\frac{5}{8}$″	38	143	5.52	23.64	Merklicher
14′	$1\frac{1}{2}$″	43	186	6.24	29.88	Merklijnen

For $3\frac{1}{8}$-inch "Little Giant" Drills For $3\frac{1}{8}$-inch "Slugger" Drills For $3\frac{3}{16}$-inch "Slugger" Drills For $3\frac{1}{4}$-inch "Little Giant" Drills For $3\frac{1}{4}$-inch "Slugger" Drills	Shank $1\frac{1}{8}$ x 6 inches $1\frac{1}{8}$-inch Steel Feed, 24 inches

2′	**$2\frac{3}{8}$″**	**10**	...	**$2.78**	....	**Merkmal**
4′	**$2\frac{1}{4}$″**	**18**	**28**	**3.74**	**$6.52**	**Merkmalen**
6′	**$2\frac{1}{8}$″**	**26**	**54**	**4.22**	**10.74**	**Merknaald**
8′	**2″**	**34**	**88**	**5.06**	**15.80**	**Merkpfahl**
10′	**$1\frac{7}{8}$″**	**42**	**130**	**6.14**	**21.94**	**Merkstab**
12′	**$1\frac{3}{4}$″**	**49**	**179**	**7.22**	**29.16**	**Merkteeken**
14′	$1\frac{5}{8}$″	56	235	7.70	36.86	Merkur
16′	$1\frac{1}{2}$″	63	298	8.90	45.76	Merkurius
18′	$1\frac{3}{8}$″	70	368	10.78	56.54	Merkwort
20′	$1\frac{1}{4}$″	77	445	11.50	68.04	Merkwortes

NOTES—A SET CONSISTS OF ONE STEEL OF EACH LENGTH. Each telegraph name, as given in the table, refers to ONE FULL SET up to the length opposite that word.

In ordering drill steels be sure to specify whether X, +, Z, or sandstone bits are wanted. Cross (+) bits will be furnished unless otherwise ordered.

Steels listed in **heavy type** are STANDARD SIZES and are known as stock steels and will be shipped unless length is specified; all other lengths given in LIGHT TYPE are SPECIAL and are made to order. When a set of steels longer than given in heavy type in above list is ordered, the bit of the longest special steel is made the diameter as given in the table for longest stock steel, and the bit diameters on all shorter steels are increased $\frac{1}{8}$-inch for each steel to maintain the same ratio of diameters. All stock steels having the same size shank and length of run are the same, regardless of the drill for which used. When ordering steels it is better to order two or more sets, so blacksmith can be sharpening one set while other is in use.

For prices of special broaching steels and bits for broach channeling, add one-third to price of regular drill steels of same size and length of shank.

For 3⅛-inch "Little Giant" Drills For 3⅛-inch "Slugger" Drills For 3¼-inch "Little Giant" Drills For 3¼-inch "Slugger" Drills	Shank 1⅛ x 6 inches 1¼-inch Steel Feed, 24 inches

Length of each Steel not including Shank	Diameter of Standard Bit	Weights		Prices		Telegraph Name of Set (See Note, page 23)
		Each Steel Lbs.	Set Lbs.	Each Steel	Set	
2′	2½″	11	...	$3.02	....	Merkzettel
4′	2⅜″	21	32	4.22	$7.24	Merkzielen
6′	2¼″	31	63	4.94	12.18	Merkzijde
8′	2⅛″	41	104	5.90	18.08	Merlango
10′	2″	51	155	7.22	25.30	Merlangus
12′	1⅞″	60	215	8.18	33.48	Merlarono
14′	1¾″	69	284	9.50	42.98	Merlassimo
16′	1⅝″	78	362	10.34	53.32	Merlata
18′	1½″	87	449	11.86	65.18	Merlatura
20′	1⅜″	96	545	13.18	78.36	Merlavamo

For 3⅝-inch "Little Giant" Drills For 3⅝-inch "Slugger" Drills	Shank 1⅜ x 6½ inches 1⅜-inch Steel Feed, 30 inches

Length of each Steel not including Shank	Diameter of Standard Bit	Each Steel Lbs.	Set Lbs.	Each Steel	Set	Telegraph Name of Set
2′ 6″	3½″	18	...	$3.80	....	Merlavate
5′	3⅜″	32	50	5.20	$9.00	Merleau
7′ 6″	3¼″	46	96	6.60	15.60	Merleranno
10′	3⅛″	60	156	8.00	23.60	Merlerebbe
12′ 6″	3″	74	230	9.40	33.00	Merleremo
15′	2⅞″	87	317	10.70	43.70	Merleresti
17′ 6″	2¾″	100	417	12.00	55.70	Merlieux
20′	2⅝″	113	530	16.10	71.80	Merlinammo
22′ 6″	2½″	126	656	17.40	89.20	Merlinando
25′	2⅜″	139	795	18.70	107.90	Merlinassi

For 4½-inch "Little Giant" Drills	Shank 1½ x 7 inches 1½-inch Steel Feed, 36 inches

Length of each Steel not including Shank	Diameter of Standard Bit	Each Steel Lbs.	Set Lbs.	Each Steel	Set	Telegraph Name of Set
3′	3¾″	26	...	$5.26	....	Merlinato
6′	3⅝″	46	72	7.26	$12.52	Merlinava
9′	3½″	66	138	9.26	21.78	Merliner
12′	3⅜″	86	224	11.26	33.04	Merlinerai
15′	3¼″	105	329	13.16	46.20	Merlings
18′	3⅛″	124	453	18.40	64.60	Merlmeise
21′	3″	142	595	20.20	84.80	Merlonge
24′	2⅞″	160	755	22.00	106.80	Merlotta

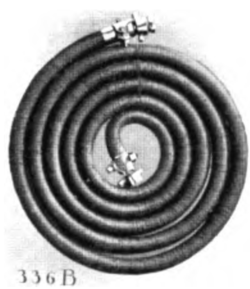
Finished Plug and Feather Bit Steels

Size	Telegraph Name	Length	Bit	Shank	Weight Pounds	Price
No. 0	Merluche	13″	1⅛″	⅝x3	1.5	$0.60
No. 1	Merlucius	20″	1¼″	¾x5	3.5	.80
No. 2	Merluzzo	18″	1¼″	1 x5½	3.5	1.35
No. 3	Mermadas	18¾″	1¼″	1⅛x6	4.0	1.50

See Notes, Page 23.

Air and Steam Hose

The air and steam hose furnished by the Ingersoll-Rand Company is made especially for the Company from the very best materials and for the special purposes for which it is intended. The sizes range from ¾ to 3 inches in diameter. It is made with 4, 5, 6, or more plies or wrappings of closely woven duck or canvas, and each style is equal to the pressure for which it is intended. The lining or tubing is of the best Para gum, properly vulcanized and treated. Several distinct styles of covering or wrapping are offered, among these are: Plain rubber; canvas covered; canvas covered marline wound; canvas covered wire wound; cotton wound and red painted jacket; marline woven jacket; special linen fabric and special linen fabric wire wound.



Marline-Wound Hose with Couplings

Marline wound hose is wrapped with a tarred marline cord, closely spaced. Wire wound hose is supplied in three styles: round wire; half round wire and flat wire. In all cases the wrapping is of galvanized steel spaced about ¼" between turns. The wire wound hose is particularly suitable for the roughest work in mine, quarrying or contract, where the hose must be dragged around over rocky surfaces. In such cases the wire protects the softer covering or jacket from injury.

Where steam is to be used, marline wound hose

Wire-Wound Hose with Couplings

is usually to be preferred to wire wound, as the latter soon becomes too hot to handle with comfort. Moreover, as the hose expands with the heat and the steam, the wire is likely to cut into the covering with an injury to the hose. Marline wound hose on the contrary will stretch as the hose expands, and there is no injury to the covering.

Where air only is to be used wire wound hose gives the best service. Steam hose may be used for either steam or air; but air hose will not last long if used with steam as the heat has an injurious effect on the lining.

Under no circumstances should oil be fed through the hose unless the tube or lining is of a special oil resisting composition, for oil rapidly destroys an ordinary rubber lining. Where steam is used the hose should be protected by the valve on the end of the pipe line, so that when the hose is not in use it may be freed from heat and pressure by closing this valve. The same application is useful where air is to be used, as it is not advisable to maintain pressure unnecessarily on the hose. But as the valve at the end of the pipe line may leak, it is better to disconnect the hose entirely if it is to lie idle for any length of time.

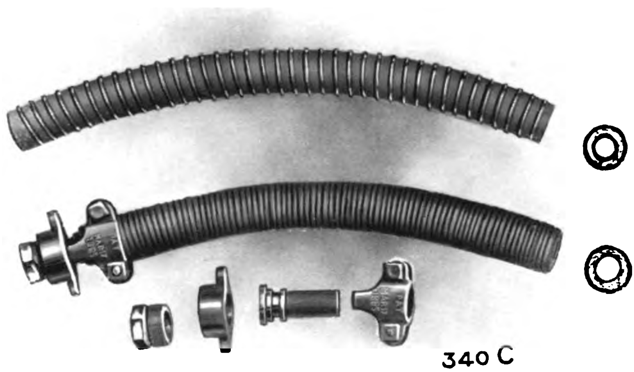
The Company is prepared to furnish hose in any style in standard lengths of 25 and 50 feet. It is never made in lengths above 50 feet, but it will be cut to odd short lengths on order. A 50-foot length is the shortest which is recommended for each drill, as this gives a wider radius of action without losing time in moving or extending pipe lines.

Owing to the great variety of sizes and styles, the Company's standard steam and air hose is not tabulated in this pamphlet. Any desired size, ply or style of covering or wrapping can be furnished on order. Most of them are carried in stock and quick delivery can be made. The larger sizes find their principal application as feeders to smaller hose lines in quarries or headings where it may not be convenient to lay a feed pipe. In such cases the manifold or header as described on page 35 is placed on the end of the large hose line and the smaller hose lines to each drill are taken off from the branch openings.

An order for hose should contain full information on the following points: The diameter of the hose; the length wanted; the pressure to be carried; whether steam or air is to be used; the style of cover (plain, marline, marline-woven or wire wound and style of wire); the number of inside plies; and whether hose is wanted with couplings or without.

Hose Couplings and Menders

The duty of the hose couplings in tunnel excavation work is particularly heavy and unless they are of the best construction they are quickly destroyed. Poor hose couplings not only will not last, but may waste many times their cost each day in the steam or



"Sergeant" Hose Couplings

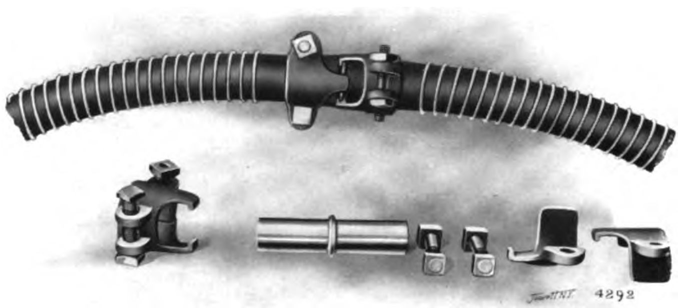
air leaking through their poor joints. This is a minor detail of economy often overlooked, but of the utmost importance.

"Sergeant" Hose Couplings

"Sergeant" hose couplings are made for the hardest service and many years of use have proved them to be the best on the market. The materials are of the best quality; they stand the most severe abuse and will hold under the highest pressures without leaking or blowing out.

"Sergeant" Hose Menders

"Sergeant" hose menders are very similar in design to the regular hose coupling and have all the good qualities of the standard couplings. They use the regular hose clamps and bolts, but the coupling stem and spud are replaced by a single mender stem, making a permanent joint.



"Sergeant" Hose Menders

Hose Couplings

Size	Complete with Spud			Size	Spud Alone		
	Price	Weight	Telegraph Name		Price	Weight	Telegraph Name
½″	$1.50	2lb. 8oz.	Lectitabis	½″	$ .35	9oz.	Lectitamus
¾″	1.50	2lb. 11oz.	Lectricem	¾″	.35	10oz.	Lectricis
1″	1.75	2lb. 13oz.	Lectulos	1″	.45	11oz.	Lecturing
1¼″	2.50	4lb. 5oz.	Ledaeos	1¼″	.80	12oz.	Ledanum
1½″	3.00	4lb. 9oz.	Ledepoppen	1½″	1.00	13oz.	Lederafval
2″	5.00	6lb. 1oz.	Lederbloem	2″	2.00	14oz.	Lederfarbe
2½″	6.00	11lb. 13oz.	Lederig	2½″	2.50	2lb. 3oz.	Lederkaese
3″	7.50	15lb. 12oz.	Ledermesse	3″	3.25	3lb.	Lederpolyp

Hose Menders

Size	Price	Weight	Telegraph Name
¾″	$1.00	1lb. 12oz.	Ledersohle
1″	1.25	2lb. 8oz.	Ledertuch
1¼″	1.50	3lb.	Ledesma

Blacksmith Tools

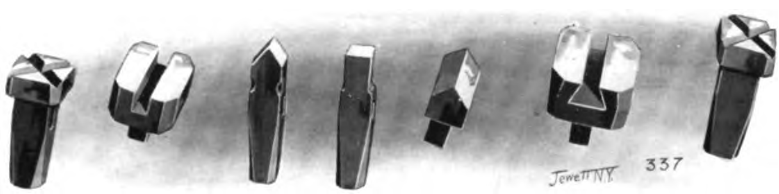
The proper sharpening of rock drill steels is a very important factor in rock drilling economy. The footage made by a drill depends very largely upon the proper forging and sharpening of

the drill bits. Bits not true to gage result in rifled holes and stuck steels. Bits not properly tempered cut down the drilling rate of the machine. A very valuable discussion of this question of drill bits will be found appended to this pamphlet.

For this important work the Company furnishes the special blacksmith tools here illustrated. They are not a part of a regular drill equipment but will be furnished on order at the prices listed on the following page. While of a special design for this

X Set

102 103 104 105 106 103X 102X



+ Set

Standard "Ingersoll-Rand" Blacksmith Tools

special class of work, they are in essentials very similar to the ordinary smith tools, and an intelligent blacksmith will quickly master their use and turn out good bits.

Two distinct styles are offered. One is for the (X) shape of bit and the other for the cross (+) bit. The order should specify which style is wanted. Standard smith tools, in either style, are made in three sizes: the "A" size, for drills 2 and 2¼ inches in diameter; the "B" size, for drills from 2½ to 3⅝ inches in diameter; and the "G" size, for drills of 4¼-inch diameter and larger. In special cases still larger tools can be furnished, on order. One set of these smith tools will handle the steels for from one to ten drills.

As sent out these tools are hardened, and ready for use. A standard set consists of sharpening tools only. Swedges for forming shanks on drill steels will be furnished on order, at the prices listed in the table.

Standard Blacksmith Tools for Sharpening Drill Steels

Shop No.	Name	"A" Size		"B" to "F" Size		"G" and "H" Size	
		Price	Telegraph Name	Price	Telegraph Name	Price	Telegraph Name
102	Dolly	$2.00	Laufpasses	$2.50	Laufseite	$3.50	Laufwagen
103	Sow	1.75	Laufplatz	2.25	Laufstock	3.25	Laufzaum
104	Spreader	1.25	Laufrad	1.25	Laufstuhl	1.25	Laufzeit
105	Flatter	1.00	Laufraeder	1.00	Laufthier	1.00	Laufzeiten
106	Swage	1.00	Laufruthe	1.00	Laufuebung	1.00	Laugenbad
Weight of set, + × lbs.		16½		+22 × 23		+27 × 33	
Price of set..... Telegraph Name		$7.00	Laufschuss	$8.00	Laufvogel	$10.00	Laugenfass

Telegraph name refers to (+) set; if (X) set is wanted follow the word for set by "ex."
Swedges for forming shanks on drill steels are not included in SET of smith's tools.
Extra price, per set, top and bottom, $2.00; separately, $1.00 each. Weight, each, 3 lbs.

Rock Drill Throttle Valves

No part of the drill is exposed to more abuse than the throttle valve, and the problem of designing a throttle, which will stand this service and still remain tight, has for many years occupied the attention of drill builders. The two devices here described have been found in this Company's experience, to give entire satisfaction.

The "Old Style" Throttle

The "Old Style" Throttle

This is a strong, heavy, straightway taper plug valve made of composition metal and designed for rough service. It has not the automatic adjustment of the "New Ingersoll" throttle and wear is taken up by tightening a nut on the end of the taper. It is a satisfactory and reliable device at moderate cost.

The "New Ingersoll" Throttle

This is an improved device of great strength and convenience, automatically adjustable for wear by the pressure and by a spring tension, easily kept tight and working freely at all times. The opening in the taper plug is at such an angle that close regulation is very easily secured. The material used is a special quality of cast steel and each throttle is individually ground and fitted at our factory. For this reason this throttle is a costly device to build and demands a higher price than some operators are willing to pay. For those requiring a cheaper valve, the throttle last described is offered.

The "New Ingersoll" Throttle

Rock Drill Throttle Valves

"New Ingersoll" Throttle			"Old Style" Throttle		
Size	Price	Telegraph Name	Size	Price	Telegraph Name
¾"	$3.00	Kourkho	¾"	$1.75	Krabschuit
1"	3.50	Kraagjas	1"	2.00	Krabsel
1¼"	6.00	Kraalrand			

NOTE—An excellent practice for operators to follow is to throw the throttle handle in opposite directions on alternate days, thus securing a uniform wear between plug and seat.

Rock Drill Oilers

The adequate lubrication of rock drills is of vital importance in its bearing on the life, capacity, sustained tightness, wear and operation of the machines. Care in looking after this detail, and the use of reliable oilers, will result in material savings. Ingersoll-Rand oilers are the most perfect devices yet made for this work and three styles are described on the following pages.

The "Reservoir" Oiler

This device is made of gun metal and comprises a reservoir of about a half-pint capacity, with a taper plug valve. The reservoir is closed with a screw plug. The taper plug has two cups on opposite sides, each holding about a teaspoonful of oil. One cup is always in communication with the reservoir and filled with oil. A half turn of the handle empties this cup into the supply passage to the drill, and the oil is carried as a spray into the machine. The other cup is filled ready for another turn of the handle. The reservoir holds enough oil for a half-shift's run and the handle should be thrown about every five to ten feet of drilling. Just the right amount of oil is admitted each time, with no loss of oil or pressure.

The "Reservoir" Oiler

The "New Ingersoll" Oiler

This is of malleable iron and closely resembles the "New Ingersoll" throttle. The taper plug has a cup on one side. When the handle is turned up, this cup can be filled with oil through the opening. Turning the handle down empties this oil into the supply pipe, whence it is carried into the drill in a spray, without loss of pressure. The throttle and oiler are usually coupled up on a T-connection, as shown. The use of the "Reservoir" Oiler is advised.


The "New Ingersoll" Oiler

The "Heart Beat" Oiler

The "Heart Beat" Oiler takes the responsibility for proper drill lubrication out of the hands of the runner and places it entirely in those of the superintendent or management. It operates by the pulsations of air in the supply pipe near the drill, due to the alternating reversals of the drill piston. It consists of

an oiler body containing a plug carrying a cartridge of wire gauze and an absorbent material. The body is screwed into a tee, to the branch of which the drill is connected, the oiler coming above the tee and the throttle.

The cartridges are carried in boxes. Three cartridges will suffice for one shift. The drill runner going on shift takes three saturated cartridges from the superintendent or other party in charge. Coming off shift, he returns three dry cartridges, which are simply dropped in a tub of oil and re-charged. There is no way of drying the cartridges except by using them in the drill and the return of dry cartridges is proof that the drill has been properly oiled. The great saving of lubricant which this oiler effects is evident. The oil is not wasted—blown out without doing useful work—but is fed slowly, as needed, and used to best effect. The "Heart Beat" Oiler will quickly pay for itself in the cost of oil it saves.

The "Heart Beat" Oiler not only enforces proper lubrication of the drill, thus reducing its wear and increasing its capacity, but also economizes lubricant and prevents excessive discharge of oil over ores, the treatment of which may be seriously interfered with by too much oil.

The "Heart Beat" Oiler

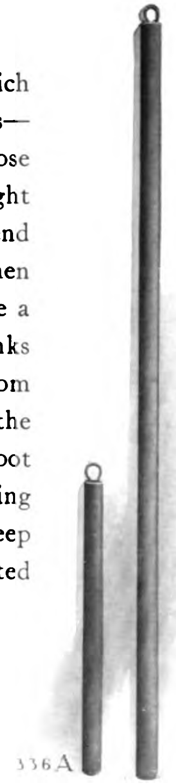
Rock Drill Oilers

Type	Size	Price	Telegraph Name
"New Ingersoll"	¾"	$3.00	Leccolli
"New Ingersoll"	1"	3.50	Lecconcino
"Reservoir"	¾"	4.50	Lecconessa
"Reservoir"	1"	5.00	Leccornia
"Heart Beat"	*	6.00	Leccume

*Furnished in only one size; if symbol of drill for which oiler is intended is given, suitable reducing tee can be furnished without extra cost.

Sand Pumps

"Down" holes in rock forming a mud which will not splash out must be cleaned at intervals—usually at every change of steels. For this purpose the sand pump is used. It is a section of wrought iron boiler tube having a valve at its lower end which opens to admit the slush, but closes when the tube is lifted. At the upper end of the tube a chain should be attached, made up of several links of rod by which the pump is forced to the bottom of the hole. A ring at the last link prevents the chain from dropping in the hole. The two-foot length is used for cleaning holes without moving the drill; greater lengths are intended for deep holes. Standard sizes and prices are tabulated below.



Sand Pumps

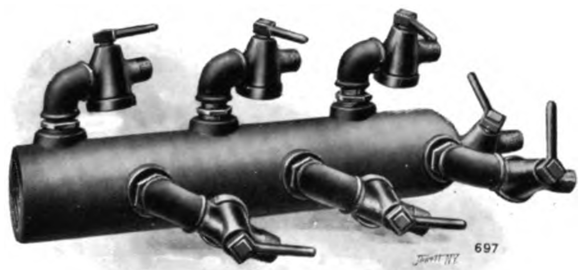
Sand Pump with Bail

		No. 1	No. 2	No. 3	No. 4	No. 5
Inside Diameter....		$\frac{3}{4}$-inch	1-inch	$1\frac{1}{4}$-inch	$1\frac{1}{2}$-inch	2-inch
Outside Diameter...		$1\frac{1}{16}$-inch	$1\frac{5}{16}$-inch	$1\frac{11}{16}$-inch	$1\frac{15}{16}$-inch	$2\frac{3}{8}$-inch
Standard Sizes	Length	Tel. Name and Price	Tel. Name and Price	Tel. Name and Price	Tel. Name and Price	Tel. Name and Price
In Stock	2′	Laubdaches $1.00	Laubfalles $1.00	Laubfleck $1.25	Laubgang $1.50	Laubhain $2.50
In Stock	4′	Lauberhuhn $1.50	Laubfink $1.50	Laubfrosch $1.75	Laubganges $2.00	Laubhainen $3.00
To Order	6′	Laubfall $2.00	Laubfinken $2.00	Laubfutter $2.25	Laubgruen $2.50	Laubholz $3.50
For each additional foot of length, add ...		25 cents	25 cents	25 cents	30 cents	30 cents

NOTE—Above prices are for pump complete with valve and bail, but do not include a chain or rod.

Manifold or Header

Where a number of machines supplied from one pipe line are operated within a limited area, as in mines, tunnel headings and in some kinds of quarry and open cut work, the manifold is used for connecting individual hose lines to the main supply. It is an extra heavy malleable casting with branch openings in strong bosses on the main casting, each furnished with a bushing, nipple,



A Seven-Branch Manifold

elbow and throttle valve of proper size, ready to couple up to the hose. Two extra holes in the end are ordinarily closed with screw plugs. The manifold is made with branch openings as indicated in the table below. The supply opening may be bushed for any size of pipe.

Manifolds or Headers

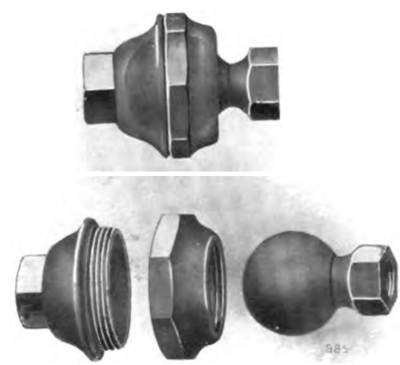
Number of Drills for which int'nded	W'gt Lbs.	Manifold with ¾-inch Throttles (New Ingersoll)		Manifold with 1-inch Throttles (New Ingersoll)		Manifold with 1¼-inch Throttles (New Ingersoll)	
		Price	Telegraph Name	Price	Telegraph Name	Price	Telegraph Name
4	47	$28.00	Lechuguero	$30.00	Lechzender	$40.00	Leckerwerk
6	55	34.00	Lechuzas	37.00	Lechzest	52.00	Leckerzahn
7	60	37.00	Lechuzo	40.50	Leciseno	58.00	Lecksaft
10	100	*	Lechzen	*	Leckermaul	*	Leckstone

Number of Drills for which intended	Weight Pounds	Manifold with ¾-inch Throttles (Old Style)		Manifold with 1-inch Throttles (Old Style)	
		Price	Telegraph Name	Price	Telegraph Name
4	44	$23.00	Lecktasche	$24.00	Lecoplaque
6	51	26.50	Leckwasser	28.00	Lecosperme
7	54	28.25	Leckwein	30.00	Lectabunt
10	93	*	Lecontite	*	Lectaremus

*Prices furnished on application.

Moran Flexible Pipe Joint

This is a ball-and-socket joint for quarry or open cut work where temporary pipe lines distribute the air or steam. Its great value is in giving flexibility over an irregular surface, especially where blasting or hoisting is going on. The angular movement is about 45° in any direction. Strong, compact, light and readily adjustable, it stands rough usage well and is the only satisfactory joint where flexibility under high pressure is essential. It entirely obviates the difficulties invariably arising with solid pipe joints in rock excavation. The Moran joint is designed to stand all ordinary pressures and is furnished tapped to the standard pipe threads indicated in the table below, which also lists the sizes and prices.



Moran Flexible Joint

NOTE—Lubrication of these joints must be provided where steam is used or where water is otherwise present; and this is most readily done by means of a small sight-feed lubricator placed on the pipe line near the boiler. But this scheme must never be used where the pipe line ends in hose, as the oil will work through and ruin the rubber tubing, unless the hose is specially prepared to resist it.

Moran Flexible Pipe Joint

Size of Pipe American Standard	Price	Telegraph Name	Size of Pipe American Standard	Price	Telegraph Name
½″	$3.25	Lectarios	2″	$7.50	Lecticaire
¾″	3.75	Lectaturam	2½″	9.00	Lecticole
1″	4.25	Lectaturis	3″	11.25	Lecticulis
1¼″	5.25	Lectaverim	4″	15.00	Lectionary
1½″	6.00	Lecteurs	6″	25.00	Lectionem

ROCK DRILL BITS

Reproduced from the *Mining and Scientific Press*

By T. H. PROSKE

The success of almost every drilling operation depends on the selection and treatment of the bits. Too much attention cannot be given this important part of the work. If the bits have been properly formed, sharpened, and tempered for the work, and if they are changed just as soon as their edges and gauges are worn, the result will be found to be most economical. The power-drill sharpener has removed many of the shortcomings attendant upon the hand-sharpening process, with the result that where these machines are used it is possible to accomplish from 25 to 100% more drilling than under the old methods. The reasons for this are that the power sharpener turns out a much better bit. The saving in the blacksmith's wages should be a secondary consideration. The superior quality of the bits made in a machine will increase the capacity of the drilling machines sufficient to pay handsome dividends on the cost of the power sharpener.

For the guidance of those unfamiliar with the forms of drill-bits used in the different sections, I have prepared a few drawings of those in use. Fig. 1 represents the square cross-bit adopted as the standard for American mining practice. It is made from either round, octagon, or cruciform steel. In the copper mines of Michigan, it is usually made of a round steel. In the iron mines of Michigan and Minnesota and wherever this form of bit is used east of the Rocky Mountains, octagon steel is preferred, but in the Rocky Mountain and Pacific States cruciform steel is used. The reason for the adoption of this form of bit as a standard will be appreciated when the three requirements of a rock-drill bit are recalled. These are 'to chisel out a hole in the rock,' 'to keep this hole round and free from rifles,' and 'to mud freely.' There is really a fourth requirement, which is 'to do as much drilling as possible before being re-sharpened.'

The different kinds of rock to be drilled affect the wear of the bit. Very hard rock will blunt the chisel and reaming edges. The softer rocks do not blunt these edges, but wear the outer sides so that it loses its gauge and size, still appearing to be quite sharp. For this reason a bit that is made with a square edge and

a clearance angle of 8° will drill about four times as long in soft rock as a bit with round edges and a clearance angle of 16°, before being reduced to the size of the next bit that is to follow. Referring to Fig. 1 and Fig. 2, the latter being a round-edge bit with a clearance angle of 16°, it will be seen that in Fig. 1 the corners of the bit at the base of the bevel describe a circle that is equal to the circle that the chisel edges describe. This is as it should be, as it is impossible for the chisel edge to cut out all of the rock. The reaming edge, which is that part of the bit extending from the chisel edge to the base of the bevel, marked 'A' in both Fig. 1 and

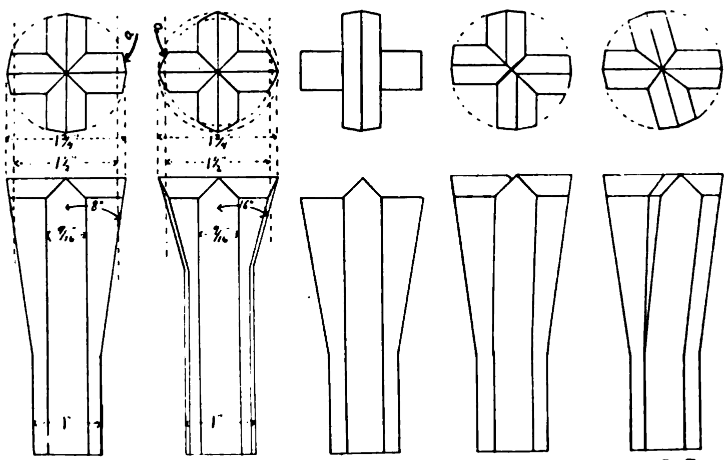


FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5
5049

Fig. 2, must ream the outer edge of the hole and keep it round and free from rifles. In Fig. 2 it will be noted that the circle described by the corners of the bit at the base of the bevel is much smaller than the circle described by the chisel edges. This causes an excess of wear on the corners of the chisel edges, the bit rapidly loses its gauge, as well as its efficiency, and it is almost impossible to keep the hole round. Rifles form, and these cause the rotation parts of the drilling machine to break, often resulting in the loss of the hole.

The angle of the bevel of the face of the bit has to do with its

life as well as with the property of 'mudding' freely. It is generally accepted that if this angle be 90° it gives strength and permits the bit to 'mud' or throw back the cuttings from the face of the bit when the drill is pointed downward. Bits made like Fig. 19 and Fig. 20 will not 'mud' freely. Another reason why bits such as is shown in Fig. 1 are preferable to those illustrated by Fig. 2, is that having a long wing they are stronger and will not break so readily as does a short bit.

The Simmons bit, used at the Champion mine at Beacon, Michigan, is shown in Fig. 3. In it two of the wings are devoted

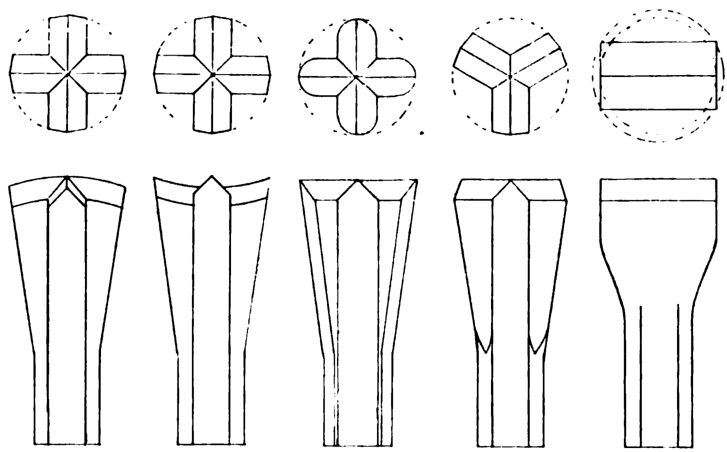


FIG.6 FIG.7 FIG.8 FIG.9 FIG.10
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entirely to reaming and keeping the hole round and free from rifles. Some tests made several years ago in jasper, the hardest rock found in the Champion mine, using a $2\frac{3}{4}$-in. Rand drill with 60-lb. air pressure at the compressor, showed an average speed per minute of 0.28 in. for the ordinary cross-bit, and 0.659 in. for the Simmons bit. Both forms were hand-sharpened.

The Brunton bit, the invention of the well known mining engineer, D. W. Brunton, is extensively used in Idaho and Montana. It is shown in Fig. 4. The object of this bit is to obtain the advantages of the X-bit without the attendant difficulties of re-sharpening. With this bit, as in the case of the X-bit, the

piston must revolve a half turn before the cutting edges will strike in the same place a second time. It is as easily re-sharpened as the regular square cross-bit. The X-bit itself is shown in Fig. 5. Since the invention of power-drill sharpening machines, this bit is fast disappearing. The reason will be understood when a comparison is made with the regular square cross-bit, as made with the power-sharpener, and the cross-bits as they are re-sharpened by hand, shown in Fig. 18, Fig. 19, and Fig. 20. The X-bit is designed to prevent rifles. This the hand-sharpened cross-bit would not do, but the machine-sharpened cross-bit

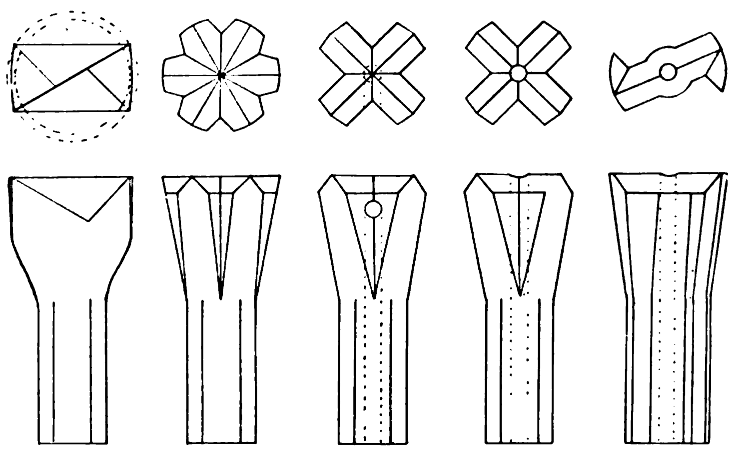

FIG. 11 FIG. 12 FIG. 13 FIG. 14 FIG. 15
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effectually accomplishes. Fig. 6 shows what is commonly termed the high-centre bit. This was for many years accepted as the proper form. It is still used in the mines of Cornwall and where Cornish customs prevail. Since the introduction of hammer-drills this bit is again finding favor. It is of especial advantage in starting a hole, the high centre immediately making an impression on the rock, whereas the square-faced bit requires a flat face for ready starting. For a starting bit in hammer machines it has no equal. Here, however, its advantages over the square bit end. Used as a bit to follow the starter, it is liable to follow slips and seams in the rock, causing crooked holes, which

are sometimes lost before being finished. This the square bit will not do. Fig. 7 shows a bit where the corners are in advance of the centre. This is a fast cutting bit. The corners break up the rock in advance of the centre and leave little for the centre to do; this causes the corners to wear fast, but still not to excess when it is considered that they do most of the work. This drill will not follow slips and seams, will drill a round hole, and is easy on the drilling machine. The weak point of this form is that the leverage is so great on the corners that they are liable to break off if tempered too hard. Fig. 8 shows the round-edge bit, which is a favorite with some. In soft rock this is good, but in hard rock it permits rifles to form in the hole because there are no reaming edges.

The Y-bit shown in Fig. 9 gives the advantage of plenty of room for the cuttings to escape. It is however, quite difficult to

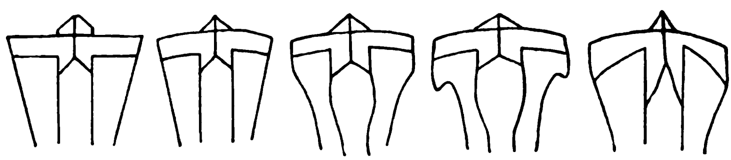

FIG. 16 FIG. 17 FIG. 18. FIG. 19 FIG. 20
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make and re-sharpen by hand. With the power-sharpener it can be made as easily as any other form. Fig. 10 shows the 'bull' bit in use in the lead and zinc mines of the Joplin, Missouri, district, before the introduction of the power-sharpener. The extreme hardness of the limestone and flint in the sheet-ground of that district, caused the ordinary cross-bit as made by hand to wear too fast. This dull bull-bit therefore had to be adopted. Drilling here was not a matter of cutting the rock, but of shattering it by impact. The power-sharpener has changed all this, and the American standard cross-bit as made in these machines is now used. As a result the capacity of the drills has been materially increased. In mines where hand-sharpening is still done the bull-bit is yet in use. Fig. 11 shows the Z-bit used in hand-sharpening in the southeast Missouri lead district. This bit is also used quite extensively in Germany. In both places, however,

the advantage of the standard square cross-bit as made with the power-sharpener is fast causing it to be displaced. Fig. 12 shows the 'six-wing rosette' bit as made in the power-sharpener in use at the Penarroya mines of Spain. It is used in hammer drills only. Of all the rosette forms of bits this has been found to be the most satisfactory. Fig. 13 shows the square cross-bits when made up for hammer drills where a hole for the introduction of air or water to remove the cuttings apexes at a point back from the bevel of the bit in one of the recesses between the wings. Fig. 14 shows the same form where the hole ends in the centre of the cross of the cutting edges. This form of bit is extensively used. Its faults are that a core is formed by this hole; this core fills the hole, and causes a stoppage of air or water. These cores have

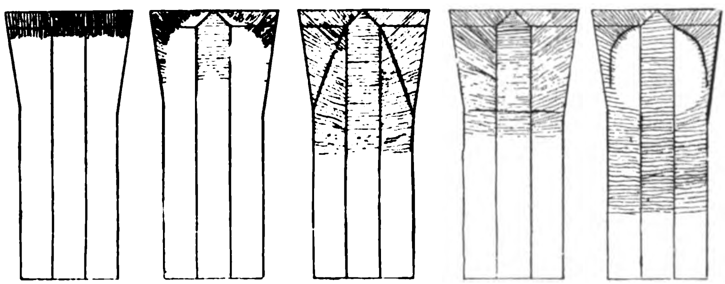

FIG 21 FIG. 22 FIG. 23 FIG. 24 FIG. 25
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been known to become as much as 8 in. long, and are quite difficult to remove. To clear them away the core must be burned out by heating the steel the full length of the core in a slow fire; a sometimes slow and tedious process. This difficulty is entirely overcome by the use of the bit shown in Fig. 13. The Z-bit, Fig. 15, is extensively used in Germany. In hammer drilling machines, the steel is formed in bars having a Z shape. While I show this bar straight, it is usually twisted to form a spiral. It is an easy matter to form a Z-bit on the end of such a bar. The results obtained are excellent. Holes to a depth of 16 ft. horizontal have been drilled with this form of steel. The spiral draws out the cuttings much the same as an auger. Fig. 16 to Fig. 20 are given to show the evolution of the cross-bit where hand-sharpening is

employed. There are two systems of hand-sharpening. One is known as the set-hammer system. In it the steel is hammered by placing a set-hammer on the bevels and driving the steel back. The results of this method are illustrated in Fig. 16 to Fig. 19. Fig. 16 shows a bit made by cutting the bevels with a chisel and is as it should be in form. Fig. 17 shows this bit after about the third sharpening. Fig. 18 is the same bit after about the sixth sharpening, and Fig. 19 is the same bit at about the time that the original cross that was formed on the bar of octagon steel has become exhausted. The other system of hand-sharpening is known as the fuller and dollie system. By this system the stock

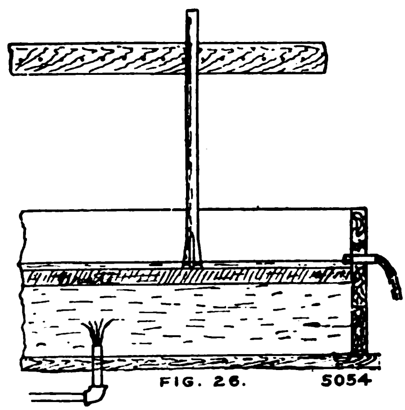


FIG. 26. 5054

is first drawn sharp at the corners as shown in Fig. 20 with the fuller, after which it should be set back in the centre with the dollie. Unfortunately the man swinging the sledge hammer gets tired before the bit is set back enough, the result is that the bit, partly finished, is left as shown in Fig. 20. It is because the power-sharpener has the staying power, and because it readily finishes a bit perfectly, that inferior bits like these are not to be found where machine sharpening is employed.

After a bit has been forged, it should be properly tempered as in Fig. 21. Fig. 22 shows the result of the common method of tempering. The centre of the bit is soft, while the corners are hard. When the bit is immersed in the water about an inch the

large mass of metal in the centre cools more slowly than the corners since the corners have three sides exposed to the water. Perhaps the centre had not chilled at all when the bit is withdrawn for annealing, and the final result is a soft-centre bit, which will flatten and retard the work of drilling. Fig. 23 and Fig. 24 show the result of trying to temper the bit with the forging heat, by plunging the whole bit into the water as soon as it is sharpened. The line of tension induced by cooling is indicated. At this place the drill will break. Fig. 25 shows the checking caused by first chilling the steel back of the bit and then plunging with the forging heat.

For the purpose of tempering a bit as shown in Fig. 21 a tank should be provided, such as shown in section in Fig. 26. This should be about 12 in. deep by 12 wide, and of sufficient length to accommodate whatever number of drills are to be sharpened in a day with the machine. The water inlet should be at the bottom, and the outlet should be placed about $\frac{3}{4}$ in. above a grate which itself should be about 8 in. above the bottom. This permits the bit to be immersed to a depth of about $\frac{3}{4}$ in. With a tempering tank of this construction the bit can be hardened to any desired degree. This depends on the temperature of the bit when placed on the grate. It is essential that the drill stand in a vertical position. To lean either way would cause it to harden to a greater depth on one side than on the other, causing a tension that might lead to breaking of the wings. It is best to provide a rail around the tank about the distance required to hold the shortest drill, and to drive pins about 3 in. apart in this rail. By placing the drills between these pegs they can be kept in a vertical position. When using this tank a small flow sufficient to displace the water heated by the cooling of the bits should be turned on to keep the supply always cool.

TELESCOPE FEED HAMMER DRILLS

INGERSOLL "CROWN" RAND "IMPERIAL"

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK
Form No. 4010 April, 1909

THE term "hammer drill" distinguishes those light machines in which the steel is not attached to and reciprocated with the piston, but is struck by the piston or hammer, as in hand drilling. Such machines are built in two types — the hand tool and the telescope feed tool — both intended for use with no fixed mechanical mounting. There are instances, however, where the latter type is successfully used with such a mounting as a tripod or column.

The Ingersoll-Rand Company now offers a complete line of hammer drills representing the most advanced practice, which may be accepted as thoroughly practical, efficient, and successful machines, fully up to the standard of quality distinguishing the Company's well known line of piston drills. The present pamphlet is devoted only to the telescope feed types, with applications as defined later in these pages.

The Work of the Hammer Drill

The hammer drill is rapidly supplanting hand drilling in every field, purely on the ground of lower cost per foot of hole drilled. The type should not be considered as a substitute for the standard piston rock drill. Its principal application is in the class of work which the larger machine never even attempted to handle, for most of the drilling in many mines is still done by hand.

While it is true that the smaller sizes of piston drills have been and are to-day used in certain classes of stoping work, they have never completely solved the stoping problem in all cases. A large part of this important work has still had to be done by costly hand methods. This may now be done with the hammer drill; and some of the larger sizes in this latter type have in some cases successfully replaced the small piston drill for even the heavier portions of this work. In many mines a change in the method of mining to meet the hammer drill on its best ground will be followed by large savings.

Drilling an upper with the "Imperial MB-12" Hammer Drill; telescope feed extended

Applications of the Hammer Drill

The hammer drill in the quarry is usually of the plain hand tool type and finds its application in drilling plug-and-feather holes, pop holes, block holes, and anchor bolt holes.

In mining practice the prevailing type is the telescope feed hammer with automatic telescope air pressure feed, though the hand tool has also a limited application. Its work here is drilling in upraises, stoping, following narrow, rich veins, squaring up, cutting hitches, trimming walls, and occasional drilling of pop holes and block holes.

In the coal mine the hammer drill is useful in cutting ditches, sumps, etc., levelling floors, taking off rolls or "horse backs," taking down roof, taking up floors, brushing entries, cutting through spars, drilling holes for trolley hangers or engineering points, cutting trolley crossovers, etc.

The work of the hammer drill in contracting replaces "mud capping" and includes block holing, "pop" shooting, drilling anchor bolt holes, breaking up old concrete or masonry foundations, piers, walls, etc., dislodging the substructure of old cable or conduit railways, and removing rock in sewer, gas, water main, or conduit trenches, in cellars, shafts, wells, etc.

The Advantages of the Hammer Drill

The hammer drill is extremely simple, having only one, or at the most two, moving parts. This means a steady reliability and ease of upkeep, with low repair costs in the present Ingersoll-Rand types.

Requiring but a moment to change steels or start a new hole, probably seventy to ninety percent of the work paid for is applied in actual drilling, while with an ordinary piston drill usually not more than two-thirds and often less than one-half the time is actual drilling time. This is a most important point in work where a large number of small, shallow, and carefully placed holes are required.

The great number of light blows of the hammer drill is less destructive of steels than the heavier blows of the piston drill. The loss of gage of the bits is not so rapid. The breaking or dulling of steels for a given footage of holes is much less than in hand drilling and usually not more than half with the hammer drill what it is with the piston drill.

The hammer drill can be used in extremely close quarters — places where no piston drill with a fixed mounting could be used, or even a hand hammer swung. Wherever a man can go he can take a hammer

drill with him. It is truly a "handy" machine, easily carried anywhere under all conditions.

No special skill is required to operate a hammer drill; and herein lies one of its greatest advantages. Only a skilled machine man can overcome a "fitchered" hole, start a difficult hole or determine the proper feed and stroke, thus getting maximum results with a piston drill. But a half day's work will familiarize any intelligent laborer with the hammer drill. One skilled miner can direct or "point" the holes for half a dozen or more hammer drills — a most important item where good men are hard to get.

It is no exaggeration to say that ninety percent of the stoping work in the mines of the world is still being done by hand. It is also a fact that one hammer drill will average an equivalent of six to fifteen hand drillers. Good labor is every year more scarce. If ten hammer drills will do the work of one hundred hand miners, they are certainly a good investment. With a limited force provided with these drills, ten times the drilling can be done and the production correspondingly increased, thus getting cheap machine results in one year which would otherwise take much longer.

The "Crown HB-10" Hammer Drill in operation; standard telescope feed extended and extension pointer run in

The "Crown HC-10" Hammer Drill putting in an upper; telescope feed and extension pointer run out, showing the advantage of this drill in high stopes

The "Imperial MC-22" Hammer Drill with reversed feed mounted on a stoping column

This advantage goes still further. Much of the economy of mining depends on the holes being properly and skilfully placed to bring out the maximum quantity of ore with the minimum powder charge and with the least amount of undesirable waste rock. It is certainly true that the average skill of ten selected hammer drill men will be higher than that of a gang of one hundred hand drillers. The importance of this point in its bearing on low mining costs and improved operating conditions will be appreciated by every mine manager.

The hammer drill enables the miner to follow a vein in a stope only wide enough for his body, bringing out the ore with maximum values and with the minimum of waste rock to be sorted or treated. One instance may be noted. A 2¼-inch piston drill stoping in a 14 to 18-inch vein gave ore values of $30 to $35 per ton. The substitution of a hammer drill brought out one-third more ore from a stope 18 inches wide than the piston drill brought out from a 3½-foot stope; and

Two "Crown HB-10" Hammer Drills in a Tennessee copper mine

A "Crown HB-10" Hammer Drill in a Nevada gold mine

values at once ran up to $80 or $90 per ton. Hoisting, sorting, and powder costs were cut in two; timbering costs were reduced two-thirds, and the total ore tonnage was increased. Power cost per shift for one drill was reduced from $3 to $1. In this case the user figured that the smaller machine was worth $1,000 per month to him.

Hammer Drill Construction

When an attempt is made to apply ordinary rock drill construction to the lighter hammer drill, failure is sure to result. It is equally true that ordinary pneumatic tool standards or designs do not apply in this case. The many hammer drills which have appeared in the last few years, only to drop from sight after a little actual service, instance the failure of such attempts. While the end to be obtained is the same with both the piston and the hammer drill, the problem must in the case of the latter be approached from an entirely different standpoint and is best met by the largest experience in machine drilling.

The necessity for light weight; the great number of blows per minute; the high velocity of moving parts; the small surfaces exposed to wear; the great depreciation following only a little wear — these are

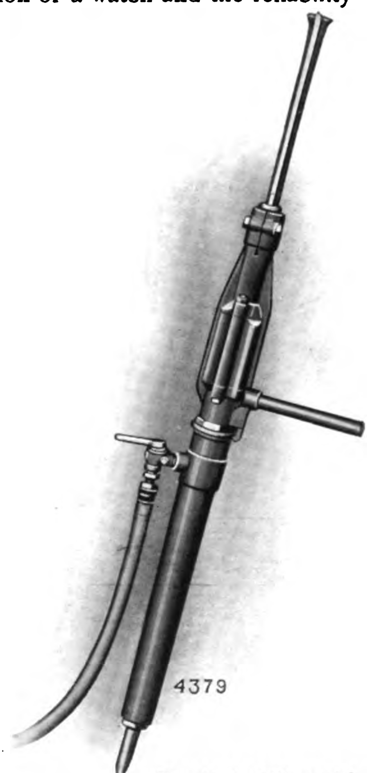
A "Crown HC-12" Hammer Drill with reversed telescope feed, mounted on a standard "A-35" Sergeant tripod with "C" weights

elements which must be provided for in the hammer drill, together with a strength and endurance equal to the most severe rock drill duty.

The rules to be followed in producing the heavier piston drill apply only partially to the manufacture of a light hammer drill. Ingersoll-Rand hammer drills, therefore, while designed in a perfect understanding of drilling requirements, represent a distinct departure from ordinary rock drill practice. Their construction approximates more that of the rapid-fire gun or the perfected high-class rifle. They are superior mechanisms in which every working part is of hardened and ground high-carbon steel, built with the precision of a watch and the reliability of a monkey wrench.

Hammer Drill Economy

Throughout every detail of design and construction of Ingersoll-Rand hammer drills, the ideal of sustained economy and capacity has been sought above all else. A machine which, when new, will drill 10 inches a minute on a claimed consumption of 40 cubic feet of air, and then rapidly drop in a few weeks or months to a rate of 1 to 4 inches on 60 to 90 cubic feet of air, cannot be compared as a successful permanent investment with a drill which, during a long period of reliable service, will put down 6 inches of hole per minute under average conditions, with perhaps less than 50 feet of air. The former figures simply suggest a prevalent condition in the hammer drill situation. The latter represent the ideal embodied in the present Ingersoll-Rand types.



The standard "Imperial MC-22" Telescope Feed Hammer Drill

Telescope Feed Hammer Drills

This pamphlet is devoted exclusively to Ingersoll-Rand Telescope Feed Hammer Drills, in Ingersoll "Crown" valve, and Rand "Im-

perial" valveless, models, in various sizes and types adapted for varying operating conditions.

The other type of hammer drill, in distinction to the telescope feed drill, is that which is held in the hand like a pneumatic tool. Such drills are used for shallow holes in mines and quarries, or in heavier types for deep down holes, as in sinking. They will be described in a separate pamphlet.

The telescope feed hammer drill, when used without a water or an air jet, is suitable only for holes above the horizontal because of the tendency of the cuttings to pack around the bit where holes run below the horizontal. For up hole service in dry rock the cuttings free themselves by dropping out of the hole, hence the steels furnished for these machines and listed on pages 26 to 28 are solid steels in either hexagon or cruciform section, as ordered.

For 'up' holes in damp, sticky ground where the cuttings will not run out by gravity, these drills can be specially furnished, on order, with a hollow anvil block for the use of hollow drill steels with an air jet through the steel for blowing out the cuttings. Prices on hollow drill steels will be furnished on application.

In down hole service the regular rock drill is the best. So far no hammer drill has equalled it, for the reciprocating movement of the piston drill clears the hole and gives the maximum cutting speed.

The Ingersoll-Rand Line

The Company's present advanced line of hammer drills includes two distinct series, differing radically in fundamental design, but alike in the care bestowed upon every detail of construction and materials.

The "H" series of Ingersoll "Crown" Valve tools has a valve movement entirely separate from the piston or hammer movement, the valve being of an "air-thrown" type moved by differences of air pressure on the faces of the valve. This valve action is positive, reliable, and of remarkable simplicity.

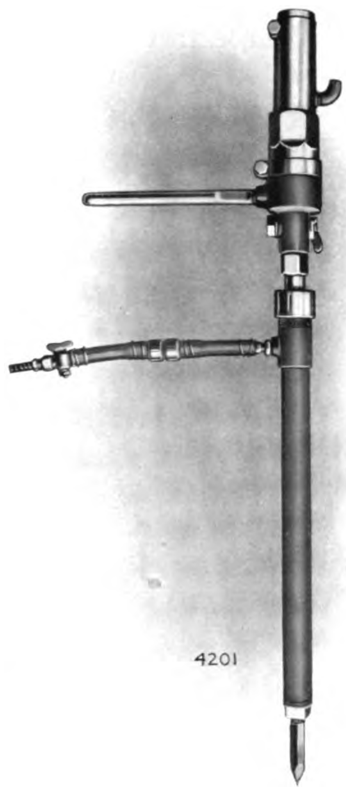
The "M" series of Rand "Imperial" Valveless tools has the admission and exhaust of air controlled by the movement of the piston itself, the latter covering or uncovering various air ports in its travel. There is thus but one moving part to the machine.

Valve Tools *vs.* Valveless Tools

The Company's experience enables it to draw with reasonable clearness the line of distinction between the proper field for the "valve" hammer drill and the "valveless" tool.

IN MOST HARD ROCKS AND WHERE LOW OR MEDIUM AIR PRESSURES ARE USED, THE VALVE TOOL, AS REPRESENTED BY THE "H" SERIES OF INGERSOLL "CROWN" HAMMER DRILLS, WILL PROBABLY GIVE THE BEST RESULTS AND IS USUALLY TO BE PREFERRED UNDER SUCH CONDITIONS.

IN SOFT OR MEDIUM ROCKS AND WHERE THE AIR PRESSURE IS HIGH, EXPERIENCE SEEMS TO SHOW THAT THE VALVELESS TOOL OF THE "M" SERIES OF RAND "IMPERIAL" HAMMER DRILLS WILL PROVE THE MORE RAPID DRILLER.



The standard type of the "Imperial MA-12" Telescope Feed Hammer Drill

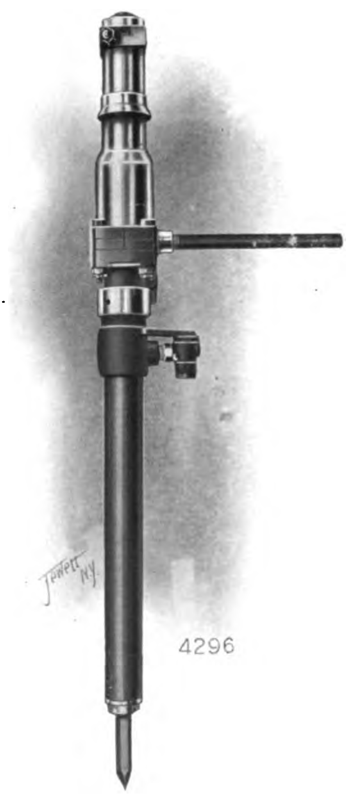
The explanation is as follows: The valve tool has a longer stroke, strikes a harder, sharper blow, and fewer blows per minute, while the valveless tool strikes a greater number of short-stroke, lighter blows. This results in a marked difference in the quality of the blow of the two drills. In hard rock the valveless tool has a tendency to pulverize rather than chip away the rock, giving relatively less penetration and tending toward the production of a larger amount of dust. The valve tool, on the contrary, appears to break away the rock in larger chips, giving less dust and cutting more rapidly. In soft rock the valve tool, with its powerful, swinging blow, appears to drive the bit into the rock without chipping, making the rotation difficult; while the valveless tool with its lighter, more rapid blow, cuts freely into chips rather than powder, cleans well with the minimum amount of dust, rotates easily, and penetrates rapidly.

It is, of course, to be understood that these are general conclusions only. It is impossible to state any hard-and-fast rule governing the application of these two types of drills, as in the final analysis the peculiar characteristics of the rock to be drilled must determine which of the

two will give the better result. The development of these two distinct types of hammer drills for seemingly similar work is simply in line with the Company's policy of examining every problem in minutest detail, with a view to furnishing the best machine for the work in hand. The Company has no interest in pushing a valve tool as against a valveless tool, or vice versa, except in so far as the customer's interest is furthered by using the drill which is the best one for his particular drilling conditions.

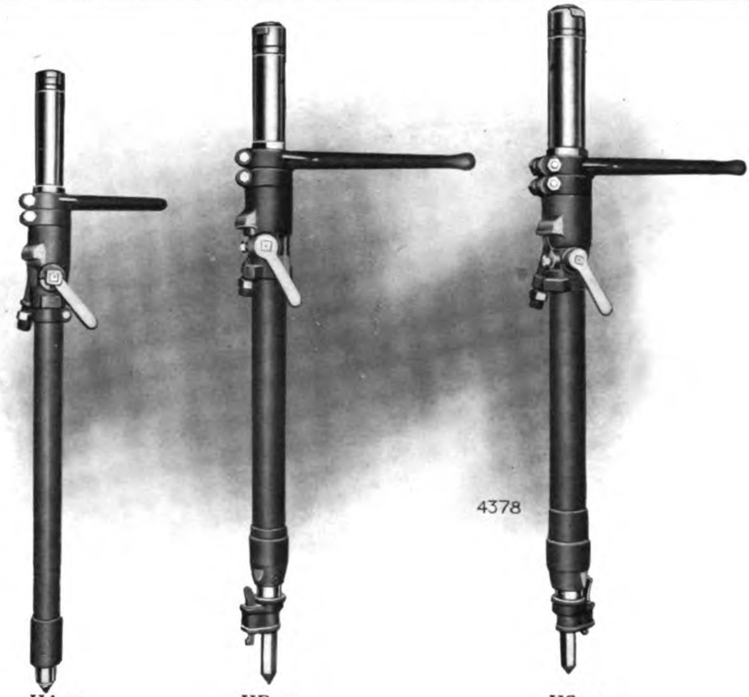
Some Important Details

In both the "H" and the "M" series all wearing parts of the drill proper are given special treatment to eliminate wear and consequent leakage. The cylinders of steel are hardened and ground in the bore. The hammers or pistons are of hardened and ground steel. In the "H" drills the valve and valve box are of hardened and ground steel. All styles use plain, solid, "shankless" steel, a hardened steel anvil block being interposed between the hammer and the butt of the steel. Chuck bushings are furnished to accommodate either hexagon or cruciform steel and orders should state which of the two cross-sections of steel is to be used, as well as the size of the steel. A small sample of the steel which it is proposed to use, if sent with the order, will be of assistance in furnishing a suitable chuck bushing, as there are several different styles of steel on the market. Some sample sections are shown on page 17.



Standard "Imperial MC-12" Hammer Drill

INGERSOLL-RAND TELESCOPE FEED HAMMER DRILLS LISTED IN THIS PAMPHLET ARE INTENDED



HA-11 Light Drill | HB-10 Medium Drill | HC-10 Heavy Drill

The three sizes of the "Crown" Hammer Drills in relative proportions

FOR UP HOLES AT ANY ANGLE GREATER THAN TWENTY DEGREES ABOVE HORIZONTAL.

The telescope extension pointer furnished on certain types is simply an auxiliary tube terminating in a steel pointer which slides inside the feed piston and is held in any position by a wedge lock fastened or released by a hammer blow. It is used to lengthen the drill when necessary for a proper set-up. A device is provided on all drills which prevents the running out of the telescope feed when the drill is being carried from place to place.

Rotation is provided in all types by handles screwed or clamped to the back head of the drill. Special care has been exercised to provide free lubrication for every working part, this feature being of vital importance in its bearing upon the life and efficiency of the machine.

Types, Sizes, and Symbols

As already stated, the "H" series of Ingersoll "Crown" tools includes all valve hammer drills and the "M" series of Rand "Imperial"

tools all valveless drills. These letters, in combination with other letters and figures, as explained below, form the symbols designating the several modifications of the basic type.

The letter "A" stands for the light drill in both series, "B" for the medium drill, and "C" for the heavy drill.

The figure "1" immediately following the letter indicating the size of the drill is the serial indicating the number of the type offered. As the type is changed this figure will be changed, running up to "9" in the order of the changes. The present types, with one exception, all have the number "1."

The figure "0" immediately following the type serial number stands for the standard telescope feed with feed cylinder attached to the drill proper and with the feed piston running out, the extension pointer being used. The figure "1" after the type number indicates the same telescope feed as the figure "0," but with the extension pointer omitted. The figure "2" following the type number designates a reversed telescope feed; i.e., the feed piston is attached to the drill with the feed cylinder, carrying the pointer, running out. No extension pointer is used in this drill, which is adapted for use with a mechanical mounting — column or tripod.

The complete symbols of the several combinations now offered to the trade thus become as follows:

Ingersoll "Crown" Valve Drills — Symbol "H"

Light Drills — Symbol "A"

Standard Telescope Feed, without Extension . . HA-11

Medium Tools — Symbol "B"

Standard Telescope Feed, with Extension . . . HB-10
Standard Telescope Feed, without Extension . HB-11
Reversed Telescope Feed, for Mounting . . . HB-12

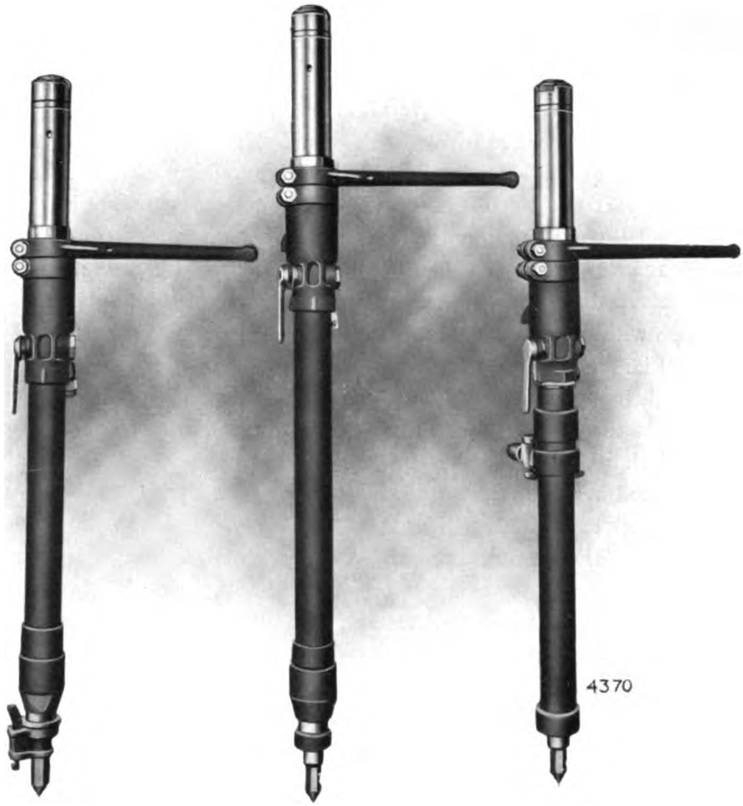
Heavy Tools — Symbol "C"

Standard Telescope Feed, with Extension . . HC-10
Standard Telescope Feed, without Extension . HC-11
Reversed Telescope Feed, for Mounting . . . HC-12

Rand "Imperial" Valveless Drills — Symbol "M"

Light Tools — Symbol "A"

Reversed Telescope Feed, for Mounting . . . MA-12



"10" Type Standard Telescope Feed With Extension Pointer — "11" Type Standard Telescope Feed Without Extension Pointer — "12" Type Reversed Telescope Feed Without Extension Pointer

The three styles of Telescope Feed furnished on "Crown" Hammer Drills

Medium Tools — Symbol "B"

Reversed Telescope Feed, for Mounting . . . MB-12

Heavy Tools — Symbol "C"

Reversed Telescope Feed, for Mounting . . . MC-12
Reversed Telescope Feed, for Mounting . . . MC-22

It will be noted from the above that the "M" series is furnished only with what is called the reversed telescope feed and is not supplied with the telescope extension pointer. It will be noted, moreover, that the telescope extension pointer is omitted in the light valve drill, as the diameter of the telescope feed is small. The specifications of these several hammer drills are tabulated on page 21.

The Question of Size and Type of Drill

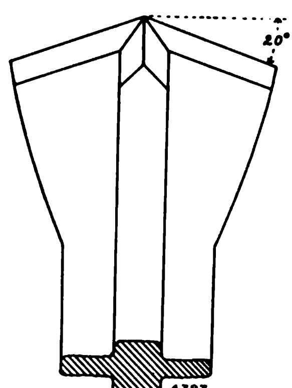
The question naturally arises at this point as to the proper field of application for these several sizes and types of telescope feed hammer drills. The drills with standard feed and no extension (Symbol "11") will serve under average mining conditions, where the stope is not too high. Drills with a telescope extension pointer (Symbol "10") are intended for work in high stopes, or where, for other reasons, a longer drill than the standard feed affords is desirable. The reversed feed drill (Symbol "12" and "22") is intended primarily for use with mechanical mountings; but as it carries a pointer on the end of its feed cylinder it may be used wherever the "11" series can be used, being preferred by some customers.

As to the size of the drill to be used, the following distinctions may be noted. Under ordinary mining conditions, where each miner has a specified average number of holes to drill in a shift, the medium sized tool, either in the "HB" or the "MB" series, will do all the work necessary. For less exacting work, or work of a lighter character than ordinary stoping in average ore, such as breaking up ore in the chutes, the light tool in either the "HA" or "MA" series will give satisfactory results. But where an unusually large number of holes are to be drilled in a limited time, or where the conditions otherwise demand exceptionally rapid work, the heavy tools in the "HC" or "MC" series should be used.

THE COMPANY GUARANTEES FOR THE "CROWN HC" AND "IMPERIAL MC" TOOLS A LARGER DRILLING CAPACITY THAN ANY OTHER TELESCOPE FEED HAMMER DRILLS ON THE MARKET.

Size and Style of Bit

Experience has demonstrated that in hammer drill work a bit with a high center gives the best result; and the steels listed on pages 26 to 28 are furnished with the bit "crowned" about twenty degrees, as indicated in the sketch. Such bits have a tendency to drill a straighter hole, as the high center naturally seeks the center of the hole while a flat bit may work off to one side. Rotation also is found to be easier with "crowned" bits.



A "crowned" hammer drill steel bit

The Company recommends the use of large bits and heavy steels, as giving more satisfactory drilling results and better breaking of the ground. A hole bottomed to take 1¼-inch powder will evidently break more rock than one bottomed for 1-inch powder. Probably five or six holes bottomed for the larger powder will break as much ore as eight or nine holes bottomed for only 1-inch powder. This means less proportionate drilling time for a given amount of breaking, with greater headway made. Rotation is also made easier where a large bit is used.

This general statement, while true so far as large stopes and large raises are concerned, must be qualified where narrow veins are to be followed or where the ground is such that heavy charges would pulverize the ore or shatter the walls. In the latter case smaller holes will serve and a smaller steel and bit may be used.

These facts have a bearing upon the choice of the proper size of drill for a given work. Where large holes and heavy breaking are wanted, the "C" size Ingersoll-Rand hammer drill, using 1⅛-inch hexagon, or 1⅛ or 1¼-inch cruciform steels, should be used. Where smaller holes will give the requisite results, the "B" or "A" size will be the proper one to select.

Cross-Sections of Steel

As already stated, Ingersoll-Rand hammer drills can be furnished for either hexagon or cruciform steels. There are, however, several

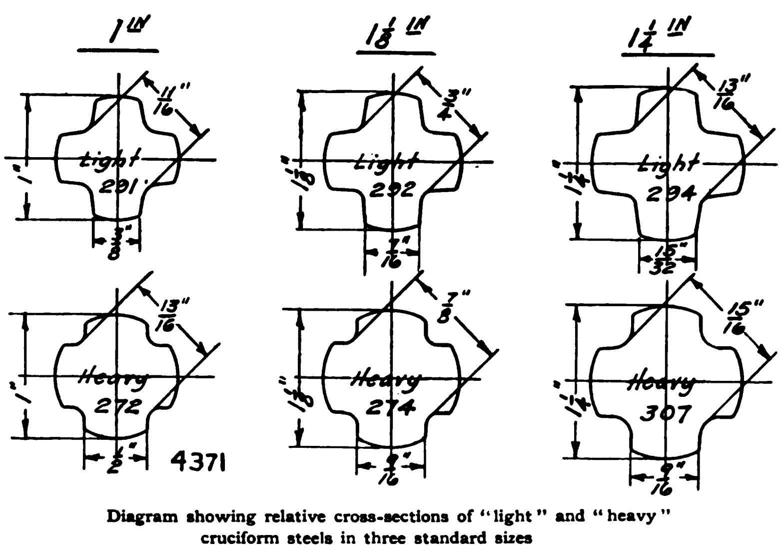
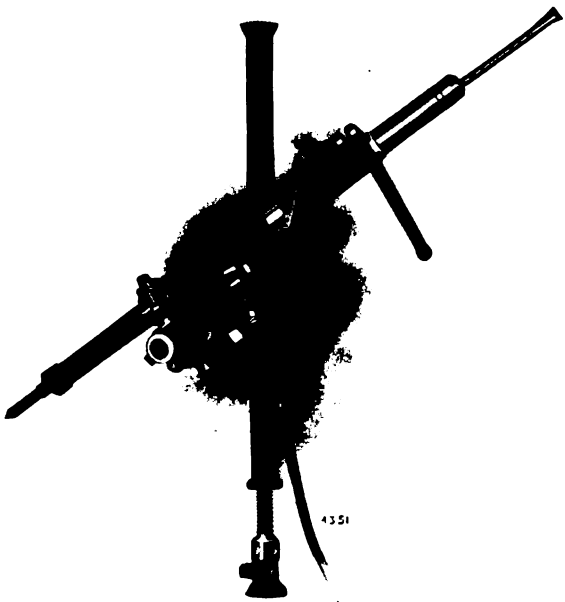


Diagram showing relative cross-sections of "light" and "heavy" cruciform steels in three standard sizes

styles of cruciform steel, some of which are found to predominate in different sections of the country. The diagrams on page 17 show the distinction between these various styles, and in ordering drills the section number given in these diagrams, indicating the steel which is to be used, should be distinctly stated.



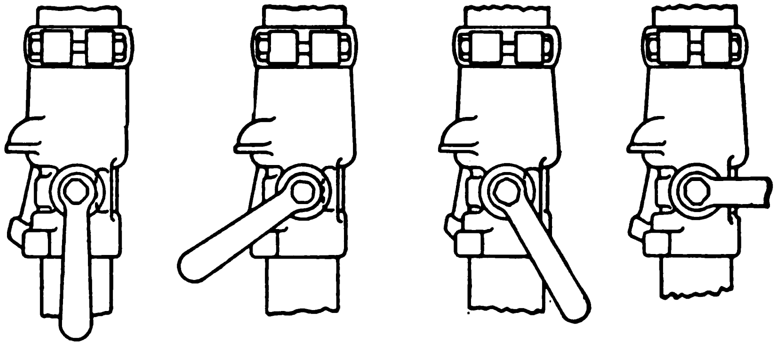
A "Crown HC-12" Hammer Drill with reversed telescope feed on single screw column mounting

Equipment

Each telescope feed hammer drill outfit is understood to include a complete drill with telescope feed, together with such fittings as may properly go with the machine in the way of valves, handles, hose connections, the necessary wrenches, etc. Hose, mounting and steels, however, are not included as a part of the regular machine outfit.

Sizes, Weights, etc.

The table on page 21 lists all the essential information about Ingersoll-Rand telescope feed hammer drills in both the "Imperial M" and the "Crown H" series and in the several types now offered.



1 2 3 4

Positions of throttle valve on "HA-11," "HB-10," "HB-11," "HC-10," and "HC-11" "Crown" Hammer Drills

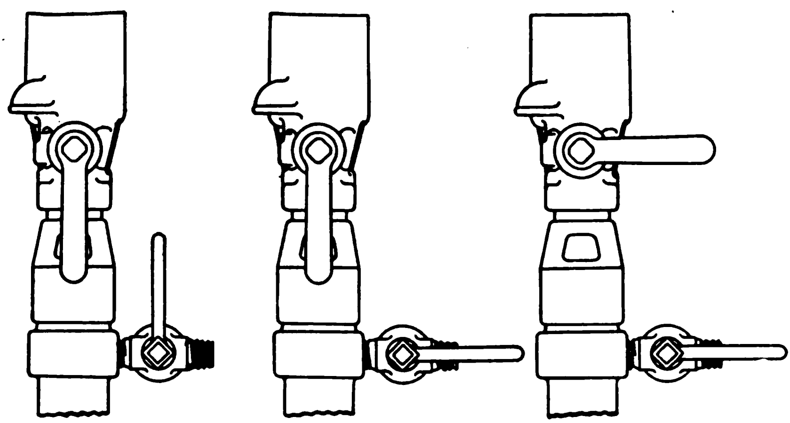
No. 1. In this position the throttle is entirely closed, air being shut off from feed and drill. The oiler is open. Oil cannot be fed to the drill with throttle in any other position

No. 2. This is the position for starting or collaring a hole. Air enters through the telescope feed to the drill, giving moderate feed pressure and drilling speed. THIS IS NOT THE FULL RUNNING POSITION

No. 3. In this position full pressure is on the feed, but the drill is not running; used in "pointing" a hole

No. 4. Full running position; maximum pressure on feed and full drilling speed

Note. — Intermediate positions will give intermediate speeds and pressures



1 2 3

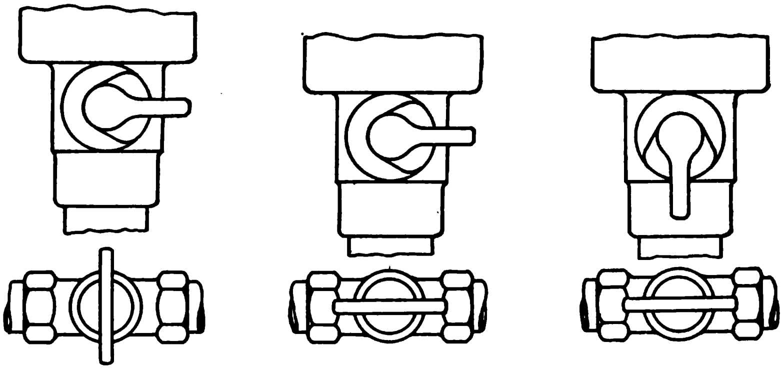
Positions of throttle valves on "HB-12" and "HC-12" "Crown" Hammer Drills

No. 1. In this position both feed and drill throttles are closed, air being entirely shut off from drill. The oiler is open. Oil cannot be fed to the drill with throttle in any other position

No. 2. Feed throttle open, drill throttle closed; full pressure is on feed but drill is not running. This position is used in "pointing" a hole

No. 3. Feed throttle and drill throttle full open, with full feed pressure and full drilling speed

Note. — Intermediate positions will give intermediate speeds and pressures



1 2 3

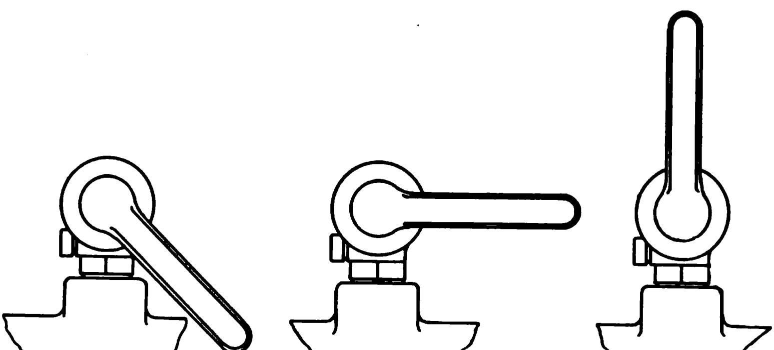
Positions of throttle valves on "Imperial MA-12" Hammer Drills

No. 1. In this position both feed and drill throttles are closed, air being shut off from the machine

No. 2. This is the position for "pointing" a hole, full pressure being admitted to the feed, but the drill not running

No. 3. Full running position, giving full feed pressure and full drilling speed

Note. — Intermediate positions will give intermediate speeds and pressures



1 2 3

Positions of throttle valve on "Imperial MB-12," "MC-12," and "MC-22" Hammer Drills

No. 1. Closed position, the air being shut off from feed and drill

No. 2. Middle position for starting a hole, with moderate feed pressure and moderate drilling speed

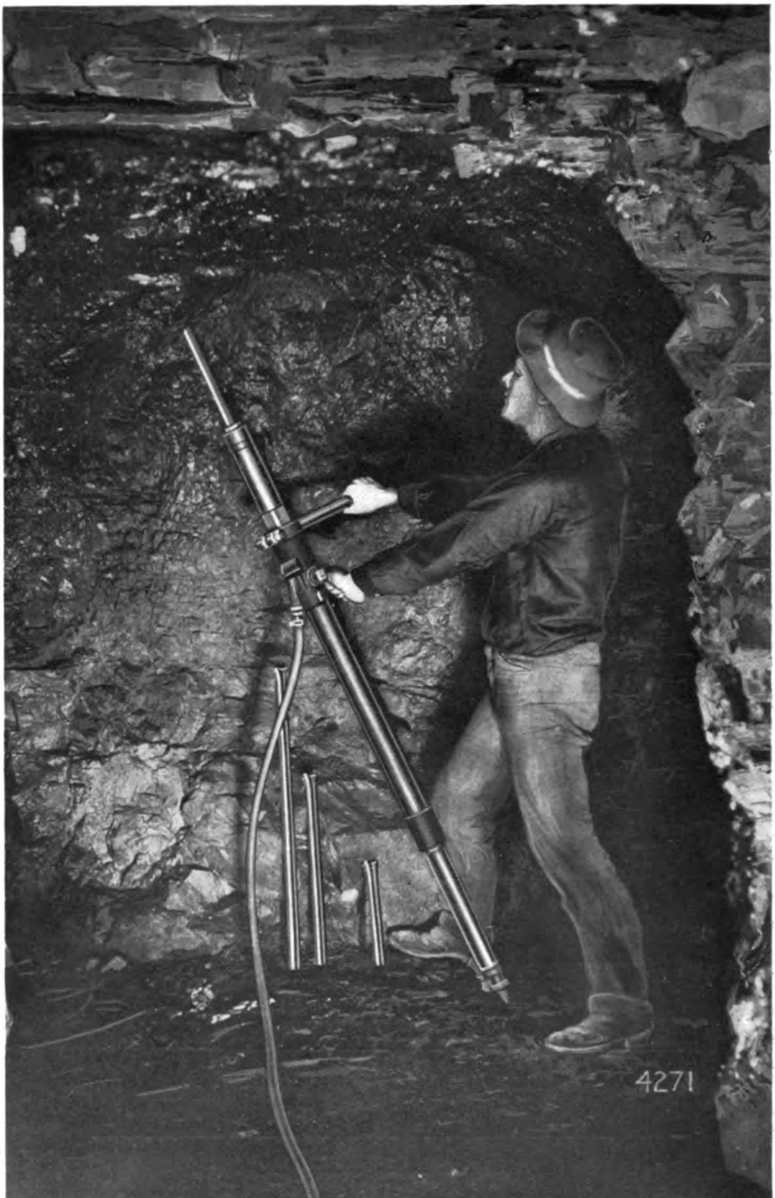
No. 3 Full running position, with full feed pressure and maximum drilling speed

Note. — Intermediate positions will give intermediate speeds and pressures

DESCRIPTIVE TABLE OF INGERSOLL-RAND TELESCOPE FEED HAMMER DRILLS

SPECIFICATIONS	"Imperial" Valveless Drills, Series "M"				"Crown" Valve Drills, Series "H"						
	Light	Medium	Heavy		Light	Medium			Heavy		
Symbol of Drill	**MA-12**	**MB-12**	**MC-12**	**MC-22**	**HA-11**	**HB-10**	**HB-11**	**HB-12**	**HC-10**	**HC-11**	**HC-12**
Diameter of Piston or Hammer, Inches	$1\frac{7}{16}$ & $1\frac{11}{16}$	$1\frac{3}{4}$ & $2\frac{1}{16}$	$1\frac{1}{8}$ & $2\frac{7}{16}$	$1\frac{3}{16}$ & $2\frac{1}{2}$	$1\frac{1}{2}$ 3/8	$1\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{5}{8}$	2	2	2
Stroke of Piston, Inches	$2\frac{1}{4}$	$2\frac{1}{2}$	3	4	$3\frac{1}{4}$	$3\frac{1}{8}$	$3\frac{1}{8}$	$3\frac{1}{8}$	4	4	4
Weight of Piston, Ounces	42	$49\frac{1}{2}$	64	46	26	43	43	43	83	83	83
Length of Drill — Feed and Extension RUN IN, Inches	*$48\frac{1}{2}$	*50	*50	*50	*50	*$51\frac{1}{4}$	*57	*52	*$53\frac{1}{2}$	*59	*$54\frac{1}{2}$
Length of Drill — Feed RUN OUT and Extension RUN IN, In.	*$68\frac{1}{2}$	*70	*70	*70	*74	*$69\frac{1}{4}$	*81	*70	*$71\frac{1}{2}$	*83	*$72\frac{1}{2}$
Length of Drill — Feed and Extension RUN OUT, Inches	*	*	*	*	*	*$90\frac{1}{4}$	*	*	*$92\frac{1}{2}$	*	*
Travel of Telescope Feed, Inches	20	20	20	20	24	18	24	18	18	24	18
Travel of Extension Pointer, Inches	*	*	*	*	*	21	*	*	21	*	*
Number of Blows Struck by Piston per Min., Air at 60 lbs. pres.	1320	1020	990	990	1200	1150	1150	1150	1050	1050	1050
Number of Blows Struck by Piston per Min., Air at 100 lbs. pres.	1560	1270	1120	1120	1400	1350	1350	1350	1300	1300	1300
Free Air Consumption, at 40 Lbs. Pressure, Cubic Feet per Min.		Not adapted for this pressure			12	25	25	25	30	30	30
" " " " 50 " " " " " "		Not adapted for this pressure			18	30	30	30	35	35	35
" " " " 60 " " " " " "	12	24	34	34	22	35	35	35	39	39	39
" " " " 70 " " " " " "	15	30	39	39	26	41	41	41	45	45	45
" " " " 80 " " " " " "	19	35	44	44	30	45	45	45	51	51	51
" " " " 90 " " " " " "	23	44	50	50	35	49	49	49	56	56	56
" " " " 100 " " " " " "	27	48	57	57	40	55	55	55	60	60	60
Size of Air Supply Hose Used, Inches	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
‡Size of Hexagon Steel Used, Inches	$\frac{7}{8}$	$\frac{7}{8}$ or 1	1 or $1\frac{1}{8}$	1 or $1\frac{1}{8}$	$\frac{7}{8}$	$\frac{7}{8}$ or 1	$\frac{7}{8}$ or 1	$\frac{7}{8}$ or 1	1 or $1\frac{1}{8}$	1 or $1\frac{1}{8}$	1 or $1\frac{1}{8}$
‡Size of Cruciform Steel Used, Inches	1	1 or $1\frac{1}{8}$	$1\frac{1}{8}$ or $1\frac{1}{4}$	$1\frac{1}{8}$ or $1\frac{1}{4}$	1	1 or $1\frac{1}{8}$	1 or $1\frac{1}{8}$	1 or $1\frac{1}{8}$	$1\frac{1}{8}$ or $1\frac{1}{4}$	$1\frac{1}{8}$ or $1\frac{1}{4}$	$1\frac{1}{8}$ or $1\frac{1}{4}$
BARE OR UNBOXED WEIGHTS, LBS. (Approximate)											
Drill Alone	**42**	**52**	**65**	**65**	**40**	**60**	**65**	**60**	**75**	**80**	**75**
6-Ft. S. S. Col. with Arm, Collar, Clamp and Feed Clamp	**	140	140	140	**	**	**	140	**	**	140
6-Ft. S. S. Col without Arm, with Collar, Clamp and Feed Clamp	**	105	105	105	**	**	**	105	**	**	105
One 50-Foot Length of Plain Air Supply Hose, with Fittings	17	29	29	29	17	29	29	29	29	29	29
BOXED OR SHIPPING WEIGHTS, LBS. (Approximate)											
Drill and Equipment (for equipment see page 17)	**75**	**85**	**98**	**98**	**80**	**100**	**110**	**100**	**120**	**130**	**120**
6-Ft. S. S. Col. with Arm, Collar, Clamp and Feed Clamp	**	190	190	190	**	**	**	190	**	**	190
6-Ft. S. S. Col. without Arm, with Collar, Clamp and Feed Clamp	**	145	145	145	**	**	**	145	**	**	145
One 50-Foot Length of Plain Air Supply Hose, with Fittings	37	50	50	50	37	50	50	50	50	50	50
PRICES (F.O.B. Factory or N. Y.) & TELEGRAPH NAMES	Vainnedad	Vainnedalo	Vainneddo	Vainnedero	Vadabagulo	Vadabahias	Vadabahira	Vadabahuba	Vadabaigne	Vadabaimar	Vadabaires
Drill and Equipment (for equipment see page 17)	**$100**	**$135**	**$135**	**$135**	**$100**	**$135**	**$135**	**$135**	**$135**	**$135**	**$135**
Six-Foot Single Screw Column, with Arm, Safety Collar, Clamp and Feed Clamp, only		Vainnedans **$52**	Vainnedeis **$52**	Vainnedha **$52**				Vadabaico **$52**			Vadabais **$52**
Six-Foot Single Screw Column, without Arm, but with Safety Collar, Clamp and Feed Clamp, only		Vainnedare **$42**	Vainnedent **$42**	Vainnedian **$42**				Vadabaida **$42**			Vadabaison **$42**

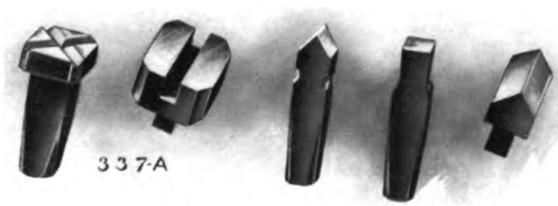
*** Not furnished with Extension Pointer.** **** Not adapted for use with Mounting.** **‡ Orders must state size and style of steel to be used (see pages 26, 27 & 28)**



A "Crown HB-10" Hammer drill in a mine stope

Blacksmith Tools

The special set of blacksmith tools here illustrated is furnished for the proper sharpening of the hammer drill steels listed on pages 26 to 28. These tools fit any anvil and their use is readily mastered by the average blacksmith. One set as listed below will sharpen the steels for from one to ten hammer drills. As sent out, these tools are not hardened and should be given proper treatment before using.



Standard blacksmith tools for sharpening hammer drill steels

Shop Number	Name	Telegraph Name	List Price
102	Dolly	Vogeledeis	$2.50
103	Sow	Vogeledent	2.50
104	Spreader	Vogeledero	1.50
105	Flatter	Vogeledha	1.25
106	Swage	Vogeledian	1.25

Weight of Set	16½ lbs.
Telegraph Name of Set	Vogeleffo
Price of Set	**$9.00**

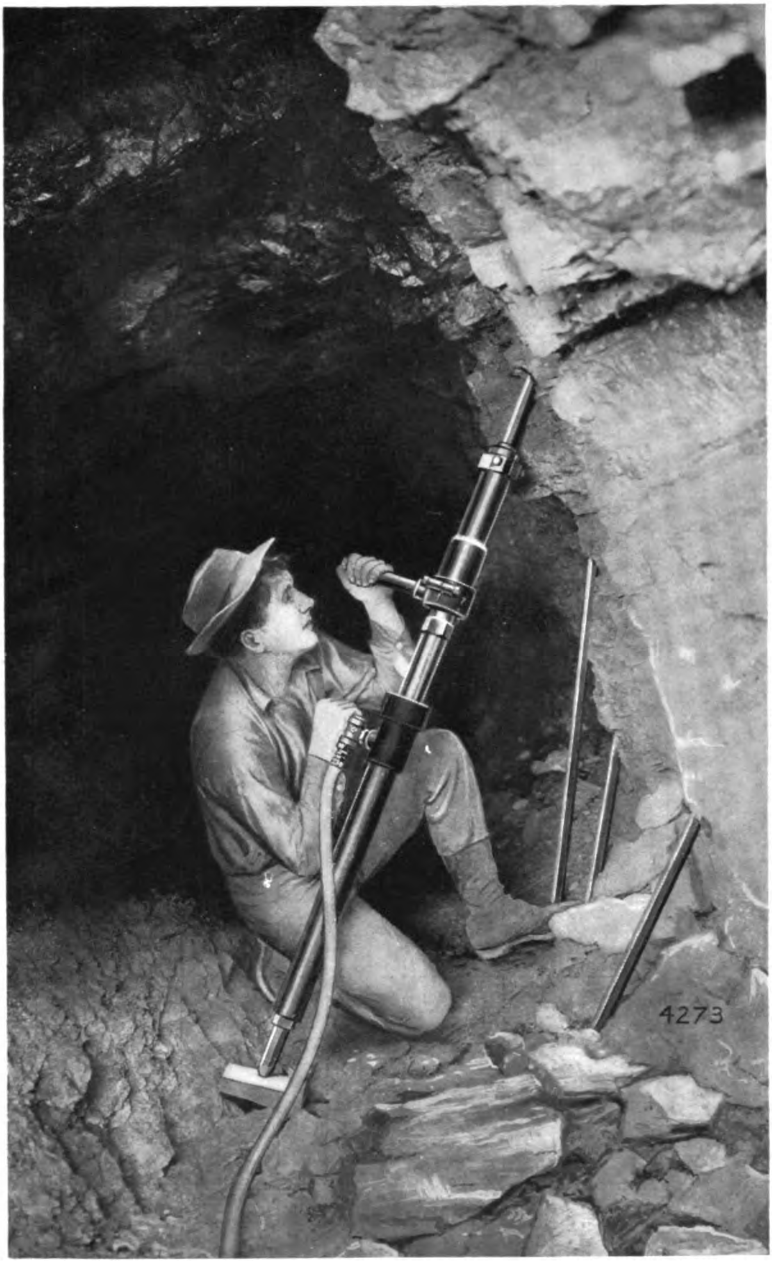
Air Supply Hose

The air supply hose furnished for Ingersoll-Rand Telescope Feed Hammer Drills is of a special brand known as "Antipeel," containing a seamless inside tube or lining that will not peel or flake off. This inner tube is covered with seven layers or plies of linen, making a strong covering and a less bulky hose than that made up with duck. This can be furnished in either the plain or wire-wound pattern, the latter being wound with a half-round steel wire with the flat next the hose. Prices, weights, etc., are given below, these including the necessary fittings at both ends of the 50-foot length.

Plain "Antipeel" air hose for hammer drills

Wire-wound "Antipeel" air hose for hammer drills

Name	Weight, Lbs.		Telegraph Name	List Price	List Price Per Foot
	Unboxed	Boxed			
50-foot Length Plain ½-inch 7-ply "Antipeel" Hose, with Couplings	17	37	Volemiora	11.75	$0.20
50-foot Length Wire-wound ½-inch 7-ply "Antipeel" Hose, with Couplings	26	46	Volemiores	12.75	0.22
50-foot Length Plain ¾-inch 7-ply "Antipeel" Hose, with Couplings	29	50	Volemiosae	14.00	0.24
50-foot Length Wire-wound ¾-inch 7-ply "Antipeel" Hose, with Couplings	39	60	Volemiosca	15.00	0.26



Stoping with an "Imperial MB-12" Hammer Drill

HEXAGON HAMMER DRILL STEELS

All the steels here listed are SOLID steels, for UP holes only, with 4-POINT CROSS bits and WITHOUT SHANK AND COLLAR

7/8-Inch Hexagon — HA or MA, HB or MB

Drilling Length Excl. of Length in Chuck, Inches	Diam. of Bit, Inches	Approx. Weight Per Steel, Lbs.	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set
Standard 6-in. Run					
6	1 3/4	2 1/4	$1.20		Volemibeis
12	1 11/16	3 3/8	1.30	$2 50	Volemibias
18	1 5/8	4 1/2	1.40	3.90	Volemibida
24	1 9/16	5 5/8	1.50	5 40	Volemiblo
30	1 1/2	6 3/4	1.60	7.00	Volemibrar
36	1 7/16	7 7/8	1.70	8.70	Volemibuca
42	1 3/8	9	1.80	10.50	Volemibum
48	1 5/16	10 1/8	1.90	12.40	Volemibuor
54	1 1/4	11 1/4	2.00	14 40	Volemicabo
60	1 3/16	12 3/8	2.10	16.50	Volemicada
Special 6-in. Run					
66	1 1/8	13 1/2	2.20	18.70	Volemicant
72	1 1/16	14 3/8	2.30	21.00	Volem'car
Standard 12-in. Run					
12	1 11/16	3 3/4	1.30		Volemicavi
24	1 9/16	5 5/8	1.50	2.80	Volemiccio
36	1 7/16	7 7/8	1.70	4 50	Volemiceas
48	1 5/16	10 1/8	1.90	6.40	Volemicela
60	1 3/16	12 3/8	2.10	8.50	Volemicero
Special 12-in. Run					
72	1 1/16	14 5/8	2.30	10.80	Volemicet

1-Inch Hexagon — HB or MB, HC or MC

Drilling Length Excl. of Length in Chuck, Inches	Diam. of Bit, Inches	Approx. Weight Per Steel, Lbs.	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set
Standard 6-in. Run					
6	2	3	$1.30		Volemichir
12	1 15/16	4 3/8	1.45	$2.75	Volemichla
18	1 7/8	5 7/8	1.60	4.35	Volemicho
24	1 13/16	7 3/8	1.75	6.10	Volemicide
30	1 3/4	8 7/8	1.90	8.00	Volemiciem
36	1 11/16	10 1/4	2.05	10.05	Volemicino
42	1 5/8	11 3/4	2.20	12.25	Volemicis
48	1 9/16	13 1/4	2.35	14 60	Volemicita
54	1 1/2	14 3/4	2.45	17.05	Volemicoba
60	1 7/16	16 1/8	2 55	19.60	Volemicolo
Special 6-in. Run					
66	1 3/8	17 5/8	2.65	22.25	Volemicone
72	1 5/16	19 1/8	2.75	25.00	Volemictam
Standard 12-in. Run					
12	1 15/16	4 3/8	1.45		Volemicule
24	1 13/16	7 3/8	1.75	3.20	Volemidaco
36	1 11/16	10 1/4	2.05	5.25	Volemidade
48	1 9/16	13 1/4	2.35	7.60	Volemidais
60	1 7/16	16 1/8	2.55	10.15	Volemidam
Special 12-in. Run					
72	1 5/16	19 1/8	2.75	12.90	Volemidava

1 1/8-Inch Hexagon — HC or MC

Drilling Length Excl. of Length in Chuck, Inches	Diam. of Bit, Inches	Approx. Weight Per Steel, Lbs.	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set
Standard 6-in. Run					
6	2 1/8	3 7/8	$1.35		Volemidens
12	2 1/16	5 1/2	1.55	$2.90	Volemideon
18	2	7 1/2	1.75	4.65	Volemidez
24	1 15/16	9 3/8	1.90	6.55	Volemidia
30	1 7/8	11 1/8	2.05	8.60	Volemidito
36	1 13/16	13	2.20	10.80	Volemidium
42	1 3/4	15	2.35	13.15	Volemidoir
48	1 11/16	16 3/4	2.50	15.65	Volemidojo
54	1 5/8	18 5/8	2.65	18.30	Volemidore
60	1 9/16	20 1/2	2.80	21.10	Volemidosa
Special 6-in. Run					
66	1 1/2	22 7/8	2.95	24.05	Volemidou
72	1 7/16	24 1/4	3.10	27.15	Volemidrem
Standard 12-in. Run					
12	2 1/16	5 1/2	1.55		Volemidulo
24	1 15/16	9 3/8	1.90	3.45	Volemidura
36	1 13/16	13	2.20	5.65	Volemiegio
48	1 11/16	16 3/4	2.50	8.15	Volemiella
60	1 9/16	20 1/2	2.80	10.95	Volemien
Special 12-in. Run					
72	1 7/16	24 1/4	3.10	14.05	Volemience

LIGHT CRUCIFORM HAMMER DRILL STEELS

All the steels here listed are SOLID steels, for UP holes only, with 4-POINT CROSS bits and WITHOUT SHANK AND COLLAR

Drilling Length, Excl. of Length in Chuck, Inches	Diam. of Bit, Inches	Approx. Weight Per Steel, Lbs.	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set	Diam. of Bit, Inches	Approx. Weight Per Steel, Lbs.	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set	Diam. of Bit, Inches	Approx. Weight Per Steel, Lbs.	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set
Standard 6-in Run	Light 1-Inch Cruciform HA or MA		HB or MB		Section 291 See Page 17	Light 1⅛-Inch Cruciform HB or MB		HC or MC		Section 292 See Page 17	Light 1¼-Inch Cruciform		HC or MC		Section 294 See Page 17
6	1 3/4	2 3/8	$0.90		Volemianos	2	2 3/4	$1.00		Volemiendo	2 1/8	3 3/8	$1 05		Volemigari
12	1 11/16	3 1/2	1.00	$1.90	Volemiardo	1 15/16	4 1/4	1.15	$2.15	Volemieras	2 1/16	5 1/8	1.25	$2.30	Volemigato
18	1 5/8	4 5/8	1.10	3.00	Volemiarea	1 7/8	5 1/2	1.30	3.45	Volemierez	2	6 7/8	1.45	3.75	Volemigena
24	1 9/16	5 3/4	1.20	4.20	Volemiasse	1 13/16	6 7/8	1.45	4.90	Volemieron	1 15/16	8 1/2	1.60	5.35	Volemigeos
30	1 1/2	7	1.30	5 50	Volemiasti	1 3/4	8 1/4	1.60	6.50	Volemierro	1 7/8	10 1/4	1.75	7.10	Volemigeur
36	1 7/16	8	1.40	6.90	Volemiate	1 11/16	9 5/8	1.75	8.25	Volemiesco	1 13/16	12	1.90	9.00	Volemigido
42	1 3/8	9 1/4	1.50	8.40	Volemiatim	1 5/8	11	1.90	10.15	Volemiese	1 3/4	13 3/4	2 05	11 05	Volemigiez
48	1 5/16	10 3/8	1.60	10.00	Volemiatur	1 9/16	12 3/8	2.00	12.15	Volemietta	1 11/16	15 1/2	2.20	13.25	Volemigior
54	1 1/4	11 1/2	1.70	11.70	Volemiavam	1 1/2	13 3/4	2.10	14.25	Volemieux	1 5/8	17 1/4	2.35	15.60	Volemiglio
60	1 3/16	12 3/4	1.80	13.50	Volemibala	1 7/16	15 1/8	2.20	16.45	Volemifado	1 9/16	18 7/8	2.50	18.10	Volemignas
Special 6-in Run															
66	1 1/8	13 7/8	1.90	15.40	Volemibans	1 3/8	16 1/2	2.30	18.75	Volemifera	1 1/2	20 1/2	2 65	20.75	Volemignia
72	1 1/16	15	2.00	17.40	Volemibebo	1 5/16	17 7/8	2.40	21.15	Volemiffas	1 7/16	22 1/4	2.80	23.55	Volemigon
Standard 12-in. Run															
12	1 11/16	3 1/2	1.00		Volemetoar	1 15/16	4 1/8	1.15		Volemiffez	2 1/16	5 1/4	1.25		Volemigram
24	1 9/16	5 3/4	1.20	2.20	Volemetrae	1 13/16	6 7/8	1.45	2.60	Volemifiat	1 15/16	8 1/2	1.60	2.85	Volemiguad
36	1 7/16	8	1.40	3.60	Volemetrez	1 11/16	9 5/8	1.75	4.35	Volemifico	1 13/16	12	1.90	4.75	Volemigunt
48	1 5/16	10 3/4	1.60	5.20	Volemetric	1 9/16	12 3/8	2.00	6 35	Volemifier	1 11/16	15 1/2	2.20	6.95	Volemijas
60	1 3/16	12 3/4	1.80	7.00	Volemettir	1 7/16	15 1/8	2.20	8 55	Volemiform	1 9/16	18 7/8	2.50	9.45	Volemijem
Special 12-in. Run															
72	1 1/16	15	2.00	9.00	Volemeumia	1 5/16	17 7/8	2.40	10.95	Volemifugo	1 7/16	22 1/4	2.80	12.25	Volemilano

HEAVY CRUCIFORM HAMMER DRILL STEELS

All the steels here listed are SOLID steels, for UP holes only, with 4-POINT CROSS bits and WITHOUT SHANK AND COLLAR

Drilling Length, Excl. of Length of Chuck, Inches	Diam. of Bit, Inches	Approx. Weight Per Steel, Lbs.	LIST PRICE Per Single Steel	LIST PRICE Per Set	Telegraph Name of Set	Diam. of Bit, Inches	Approx. Weight Per Steel, Lbs.	LIST PRICE Per Single Steel	LIST PRICE Per Set	Telegraph Name of Set	Diam. of Bit, Inches	Approx. Weight Per Steel, Lbs.	LIST PRICE Per Single Steel	LIST PRICE Per Set	Telegraph Name of Set
Standard 6-in. Run	Heavy 1-Inch Cruciform HA or MA		HB or MB		Section 272 See Page 17	Heavy 1⅛-Inch Cruciform HB or MB		HC or MC		Section 274 See Page 17	Heavy 1¼-Inch Cruciform HC or MC				Section 307 See Page 17
6	1 3/4	2 1/2	$0.90		Volemilca	2	3 1/8	$1.00		Voleminago	2 1/8	3 1/2	$1.05		Voleminhos
12	1 11/16	3 3/4	1.00	$1.90	Volemile	1 15/16	4 5/8	1.15	$2.15	Volemimeca	2 1/16	5 1/4	1.25	$2.30	Volemini
18	1 5/8	5	1.10	3.00	Volemilega	1 7/8	6 1/4	1.30	3.45	Voleniment	2	7	1.45	3.75	Voleminien
24	1 9/16	6 1/4	1.20	4.20	Volemilejo	1 13/16	7 7/8	1.45	4.90	Volemimes	1 15/16	8 3/4	1.60	5.35	Voleminina
30	1 1/2	7 1/2	1.30	5.50	Volemilete	1 3/4	9 3/8	1.60	6.50	Volemimian	1 7/8	10 1/2	1.75	7.10	Voleminize
36	1 7/16	8 3/4	1.40	6.90	Volemilhao	1 11/16	11	1.75	8.25	Volemimila	1 13/16	12 1/4	1.90	9.00	Voleminoid
42	1 3/8	10	1.50	8.40	Volemilhem	1 5/8	12 1/2	1.90	10.15	Volemimor	1 3/4	14	2.05	11.05	Voleminola
48	1 5/16	11 1/4	1.60	10.00	Volemiliam	1 9/16	14	2.00	12.15	Volemimuda	1 11/16	15 3/4	2.20	13.25	Voleminoso
54	1 1/4	12 1/2	1.70	11.70	Volemilid	1 1/2	15 5/8	2.10	14.25	Voleminae	1 5/8	17 1/2	2.35	15.60	Volemio
60	1 3/16	13 3/4	1.80	13.50	Volemilimo	1 7/16	17 1/8	2.20	16.45	Voleminicor	1 9/16	19 1/4	2.50	18.10	Volemiogmo
Special 6-in. Run															
66	1 1/8	15	1.90	15.40	Volemilire	1 3/8	18 3/4	2.30	18.75	Volemindad	1 1/2	21	2.65	20.75	Volemiolam
72	1 1/16	16 1/4	2.00	17.40	Volemillai	1 5/16	20 1/4	2.40	21.15	Volemineam	1 7/16	22 3/4	2.80	23.55	Volemioli
Standard 12-in. Run															
12	1 11/16	3 3/4	1.00		Volemillez	1 15/16	4 5/8	1.15		Voleminelo	2 1/16	5 1/4	1.25		Volemionar
24	1 9/16	6 1/4	1.20	2.20	Volemillis	1 13/16	7 7/8	1.45	2.60	Voleminer	1 15/16	8 3/4	1.60	2.85	Volemionda
36	1 7/16	8 3/4	1.40	3.60	Volemillum	1 11/16	11	1.75	4.35	Volemineta	1 13/16	12 1/4	1.90	4.75	Volemionem
48	1 5/16	11 1/4	1.60	5.20	Volemilogo	1 9/16	14	2.00	6.35	Volemingai	1 11/16	15 3/4	2.20	6.95	Volemionne
60	1 3/16	12 3/4	1.80	7.00	Volemilos	1 7/16	17 1/8	2.20	8.55	Volemingo	1 9/16	19 1/4	2.50	9.45	Volemions
Special 12-in. Run															
72	1 1/16	16 1/4	2.00	9.00	Volemilyba	1 5/16	20 1/4	2.40	10.95	Volemingue	1 7/16	22 3/4	2.80	12.25	Volemiopea

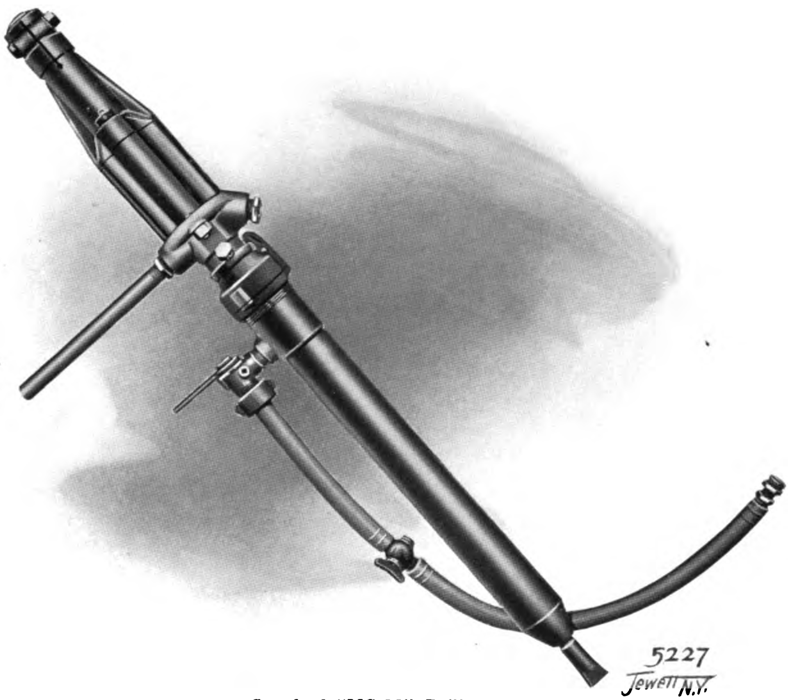
"Imperial" Valveless Telescope Feed Hammer Drill

(Type "MC-22")

Ingersoll-Rand Company

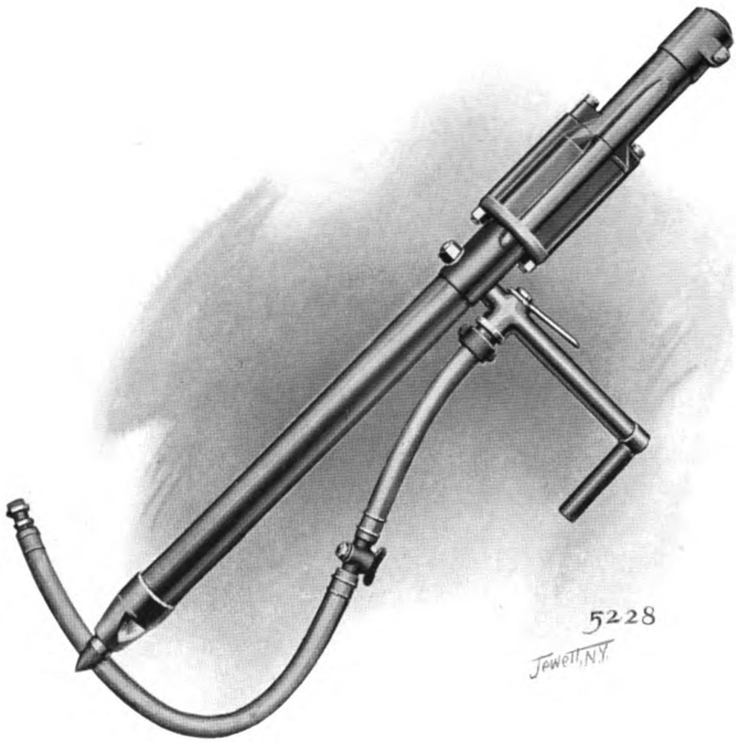
11 Broadway, New York

Form No. 4016 April, 1911



Standard "MC-22" Drill

AMONG the multitude of hammer drills now on the market, there are two basic types into which all may be classified. One is the "valve" type, in which the action of the striking piston, or hammer, is controlled by a separate valve. The other is



Imperial "MC-21" Drill differing from the "MC-22" only in having the Standard Telescope Feed. This is a Special Construction

the "valveless" type, in which the piston or hammer itself performs the valve functions by covering or uncovering ports which control its forward-and-back movement.

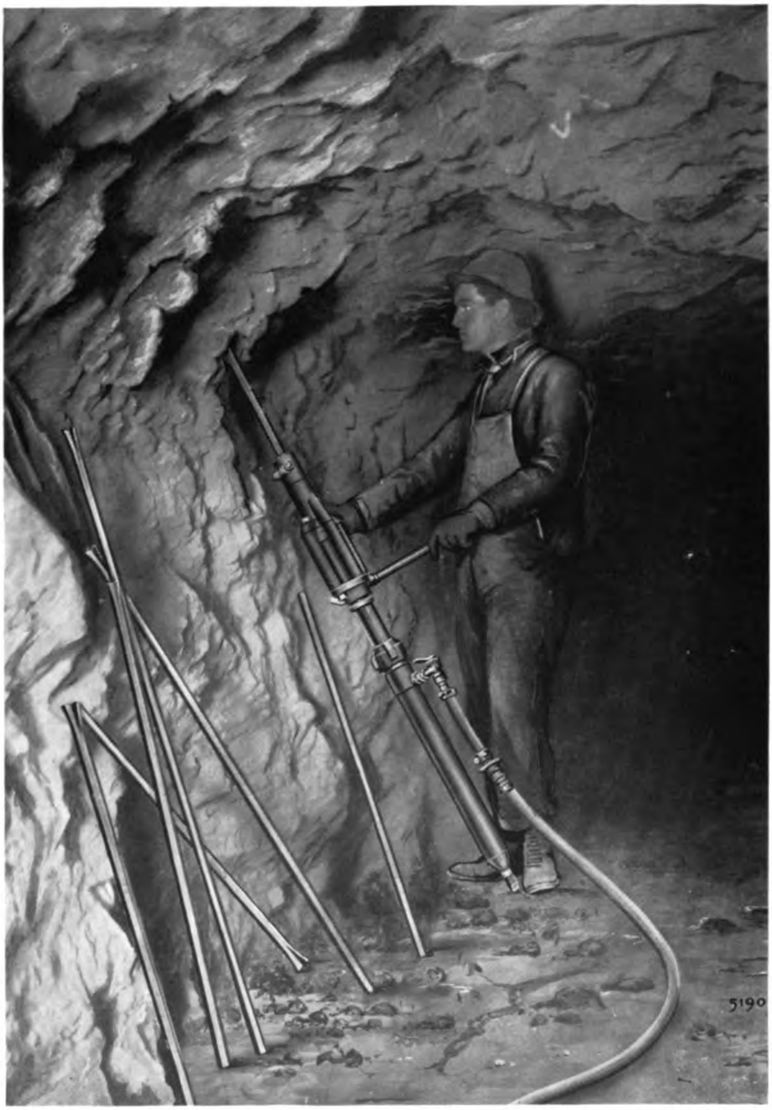
Choice between these two types is largely a matter of personal preference. There are large users of valve drills who would not consider a valveless tool. On the other hand, equally large users are equally strong in their advocacy of the valveless type. The Ingersoll-Rand Company, as manufacturers of both types of hammer drill, are non-partisan in this matter and aim only to furnish the trade with the best machine in either type, as preferred.

The "MC-22" Hammer Drill, the subject of this pamphlet, is a valveless tool and the heaviest one in this type made by the Company. It is intended for stoping, raising and, to a limited extent, drifting. But it is not recommended for steady work in holes at less than twenty degrees above the horizontal, because of the difficulty of cleaning such holes. The great field for the hammer drill is in "uppers", where the holes are self-cleaning; and in this class of work the "MC-22" comes up to every standard.

For years the valveless drill suffered under the stigma of being uneconomical, unreliable, short-lived, and of small capacity. The difficulties, from long repetition, came to be considered inherent and unavoidable in a valveless tool. The shortcomings, however, were the result of poor design and construction, rather than of the valveless principle itself. Soft cylinders and pistons, narrow ports and "bridges", inadequate bearing surfaces, poor materials, careless workmanship—these were the causes of valveless tool troubles, and not the mere absence of a controlling valve.

The "MC-22" Hammer Drill is the result of a conviction, on the part of the Company, that a satisfactory and successful valveless drill could be built; and of a persistent effort to demonstrate the truth of that conviction by producing a valveless hammer drill from which the (so-called) inherent defects had been eliminated. The performance of this improved drill proves the correctness of this conviction, for the machine has realized the most sanguine expectations of its builders and met every requirement of practical work.

A few of the contributing factors may be grouped here, and dwelt upon more fully later: Cylinders and piston of hardened and ground steel; very generous bearing and wearing surfaces; large ports and wide bridges; through bolts replacing screwed cylinder connections; large reduction in the number of screwed joints, by machining parts from steel forgings; special grades of steel used; splendid workmanship; automatic lubrication; extreme simplicity due to small number of parts. All of these features are to be compared with the cheap, make-shift construction of other valveless hammer drills. THE



Drilling an upper with the "MC-22" Drill

COMPANY UNHESITATINGLY OFFERS THE "MC-22" AS THE BEST VALVELESS HAMMER DRILL ON THE MARKET TODAY; and any unbiased comparison will justify this claim.

As to economy, two elements enter into hammer drill efficiency—cost of up-keep, and air consumption. As to cost of up-keep on the "MC-22", its construction is such that it will probably outwear and outlast any valveless hammer drill on the market today. The air consumption of the "MC-22" is less than that of any other hammer drill today offered to the trade.

The telescope feed of the "MC-22" is that designated by the Company as the "reversed feed" type, in which the inner, or piston, tube is attached to the drill, and the outer, or cylinder, tube runs out under pressure. The advantage of this arrangement is that the hose is stationary—not turning with the drill; and the tool may be used on a tripod or column by clamping the outer feed cylinder to the mounting. The "Standard feed", in which the outer tube is attached to the drill, can be furnished on special order.

Some Notes of General Construction

In the "MC-22" the ideal has been a *sustained* economy, not merely an initial or test economy. With this in view, the possibilities of various materials have been made a special study, in order that every wearing part might have the greatest possible resistance to wear, thus guarding against leakage and loss of efficiency. In probably no other hammer drill has greater care been given to the selection of materials. The front and back cylinders are made from steel drop forgings, case hardened and accurately ground to size. The nozzle (or chuck), the anvil block and the piston (or hammer) are made of tungsten vanadium steel, hardened. In other parts selected steels of the best quality and of special characteristics are used.

The air ports and passages are very large—a great advantage where dirt is to be encountered, as foreign matter entering the tool is blown out and does not clog the action. This feature also makes

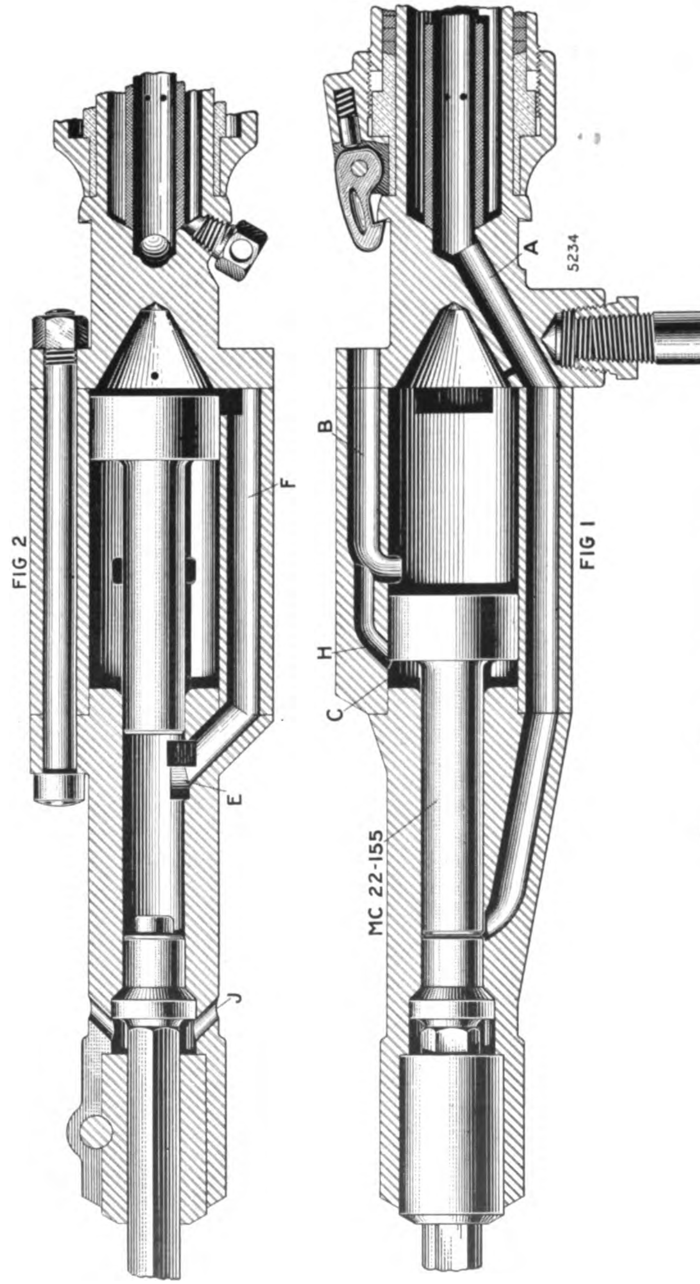


Diagram of action of Imperial "MC-22" Drill

a very quick-acting, powerful tool, with no delayed action due to inadequate air passages.

All threads used are of A. L. A. M. Standard—a great advantage in a machine subjected to such great vibration as the hammer drill. Through-bolts are of generous proportions and this means of holding together the parts is in line with the most modern practice.

The "MC-22" uses all styles of plain, solid, shankless steels, the anvil block interposing between hammer and butt of steel. Nozzles or chuck bushings can be furnished to take square, hexagon or cruciform steel and orders should designate size and style of steel to be used.

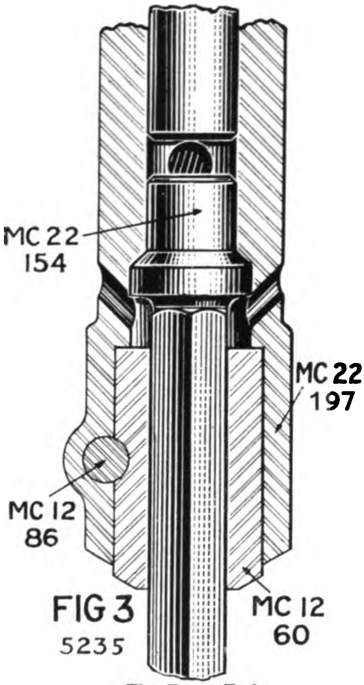
The Working of the Drill

Referring to Fig. 1, the sectional illustration herewith. Live air enters from the feed cylinder through port "A" and is carried to the front of the piston "MC-22-155", where it is at full pressure at all times. The illustration shows the piston ready for its back or return stroke. The live air at the front forces the piston back, the exhaust from behind it passing out through ports "B" until the latter are closed by the head of the piston.

The piston is moved back until port "E", Fig. 2, is uncovered, when live air is admitted to the top of the piston through the port "F". As the area of this face of the piston is greater than that of the opposite face or striking end, the piston is forced forward. Live air is shut off on the forward stroke as soon as the piston passes over port "E". The piston then is forced forward by expansion of the air until its head uncovers the exhaust port "B" just as the blow is struck on the steel.

The drill may be run without injury even with no steel in place, for an air cushion is formed in the chamber "C" as soon as the piston covers the exhaust port "H".

It is impossible for dirt to work its way into the drill through ports "J" or around the steel, as there is just enough leakage around the anvil block, due to vibration, to allow live air to blow out.



The Front End

The Front End

Referring to the illustration, Fig. 3, the construction of this important part is plain. The cylinder, "MC-22-197", is fitted with a chuck bushing or nozzle, "MC-12-60", which is held in place and prevented from turning by a bolt, "MC-12-86". The latter passes through the cylinder and engages a groove in the side of the nozzle. The cylinder is slotted to allow it to be drawn up tight, holding the nozzle firmly in position. This construction makes it easy to change nozzles for various sections of steels and to remove the anvil block, "MC-22-154".

The Telescope Air Feed

This is a very simple construction shown in Fig. 4, consisting of the outer tube or cylinder, "MC-22-135", and the inner tube or feed piston, "MC-22-120". Both tubes are made from steel forgings, in a solid piece, with no screwed joints to work loose; and this makes an exceptionally strong and rigid construction.

The spud, "MB-12-50", is screwed directly into the pointed end of the outer tube. On the other end of this tube is screwed the packing nut or stuffing box, "MC-22-122", which is illustrated and described later. An oiler "C" is screwed into the interior of the inner tube, this detail also being described later.

In operation, air is taken into the inlet "A" and passed between the inner and outer feed tubes until it reaches port "B", where it enters the inner tube and passes thence to the hammer. Into the end of the inner tube is fastened a plate "C". There is sufficient clearance

between the head "D" of the inner tube, and the inner wall of the outer tube to allow air to pass into the chamber "E". This forces the air feed open. When the ports "B" pass under the shoulder "F" of the outer tube, air is shut off from the hammer. But the air feed is still under pressure and will remain so until relieved through a bleeder in the throttle. Particular attention is called to the fact that when the air feed is fully run out, air is automatically shut off from the drill. This prevents damage and adds to the life of the tool.

The working area of the air feed is the area of the inner tube at its small diameter, at "H". In cases where this gives too strong a feed, the Company can provide for other conditions, on order, by reducing the diameter of the inner tube at "H". This necessitates a special packing gland and packing.

The Oiler

Inside of the inner tube, "MC-22-120", is screwed the oil tube "A" over which is pressed a round lamp wicking "B", Fig. 5. A series of holes "C" are drilled around the oil tube. Through this tube the air passes to the hammer. The oil chamber "D" is filled with oil by removing the oil hole plug, "MC-22-224". About three teaspoonfuls will run the drill for three shifts.

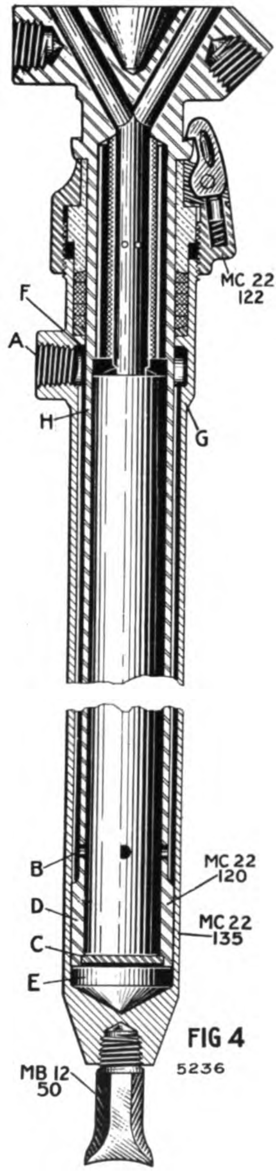
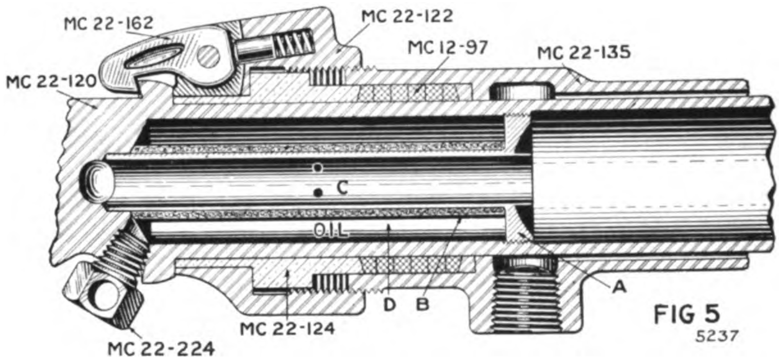


FIG 4

Section of the Telescope Air Feed



Oiler, Feed Packing Nut and Feed Lock

The wicking will take up the oil much the same as the wick of a lamp. When the drill is running, air pressure is in the oil chamber "D". As soon as the drill stops, this pressure is relieved and the air "D" expands through the holes "C", carrying with it the oil in the wick around the ports. On starting up, this oil is carried into the drill and is sufficient to keep the machine well lubricated.

The Air Feed Packing Nut

In this detail (Fig. 5) the outer tube, "MC-22-135", is screwed to the packing nut, "MC-22-122". The latter is adjustable, taking up the packing, "MC-12-97", by means of the bronze packing gland, "MC-22-124". This gland is keyed to the outer tube to prevent its rotation under the rocking back and forth of the hammer.

Particular attention is called to the fact that if the regular packing is not available, candle wicking, rope or old waste can be used temporarily. This style of packing is much more easily replaced than cup leathers.

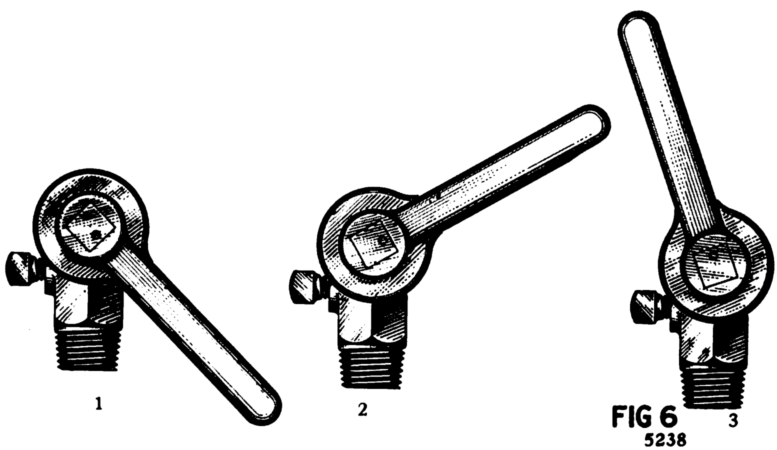
The Feed Lock

Referring to Fig. 5, the telescope air feed is locked, when run in, by means of the feed lock "MC-22-162" which is fastened to the packing nut "MC-22-122". This engages automatically over the

shoulder on the inner tube "MC-22-120" when the feed is closed, making the drill easy to handle.

Positions of the Throttle

On the "MC-22" Drill there are three major positions for the throttle lever (Fig. 6). No. 1 is the closed position, air being shut off entirely from telescope air feed and hammer. No. 2 is the middle position, for starting a hole with moderate feed pressure and moderate drilling speed. No. 3 is the full running position with full feed pressure and maximum drilling speed. Between these major positions intermediate speeds and pressures may be had.



Positions of the Throttle

Hose Equipment and Couplings

Each "MC-22" Drill is fitted with a short length of hose as shown in Fig. 7. The end "A" is screwed to the throttle and the end "C" to the main hose line. Thus, by shutting off the stop-cock "B", the drill may be disconnected from the hose line at "A" without shutting off the main line.

This hose may be connected at "C" with the standard ¾-inch Ingersoll-Rand Hammer Drill Coupling, or, by means of a standard bushing with the standard 1-inch Ingersoll-Rand Rock Drill Coupling.

Equipment

Each "MC-22" Drill outfit includes a drill complete with telescope air feed and the hose equipment as described, together with such fittings as may properly go with the machine in the way of throttle, rotating handle, wrenches, etc. No hose, mountings, or steels are a part of the regular equipment.

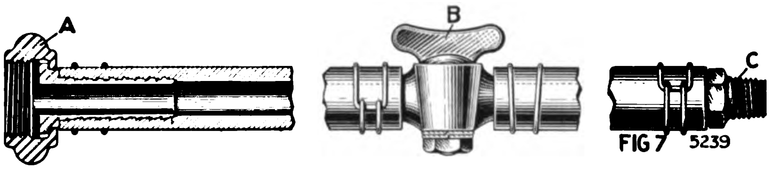


FIG 7 5239

Specifications

The following brief list presents the important dimensions and other data relating to the "MC-22" Hammer Drill:

Piston Diameter	$1\frac{3}{16}$ and $2\frac{1}{2}$ inches
Stroke	4 inches
Length of Feed	20 inches
Length of Drill, closed	50 inches
Length of Drill, open	70 inches
Weight boxed	100 lbs.
Weight unboxed	65 lbs.
Size of Air Supply	$\frac{3}{4}$ inches

The following air consumptions have been recorded for these tools:

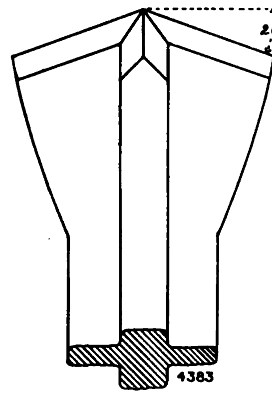
Air Pressure	Cubic Feet Free Air Per Minute
60	27
70	30
80	34
90	39
100	45

Size and Style of Bit

Experience has demonstrated that in hammer drill work a bit with a high center gives the best result; and the steels listed on page 14 are furnished with the bit "crowned" as indicated in the sketch.

The Company recommends the use of large bits and heavy steels, as giving more satisfactory drilling results and better breaking of the ground. A hole bottomed to take $1\frac{1}{4}$-inch powder will evidently

break more rock than one bottomed for 1-inch powder. Probably five or six holes bottomed for the larger powder will break as much ore as eight or nine holes bottomed for only 1-inch powder. This means less proportionate drilling time for a given amount of breaking, with greater headway made, and fewer steels to sharpen and transport. Rotation is also made easier.



A "Crowned" Hammer Drill Steel Bit

This general statement, while true so far as large stopes and large raises are concerned, must be qualified where narrow veins are to be followed or where the ground is such that heavy charges would pulverize the ore or shatter the walls. In the latter case smaller holes will serve, and a smaller steel and bit may be used.

The cut shows standard sections of cruciform steel. Squares or hexagons can also be furnished. The size to be used should be specified when ordering drills. Chuck bushings, or nozzles, will be made for any section of steel. When special sections are wanted a sample of the steel should be submitted with order.

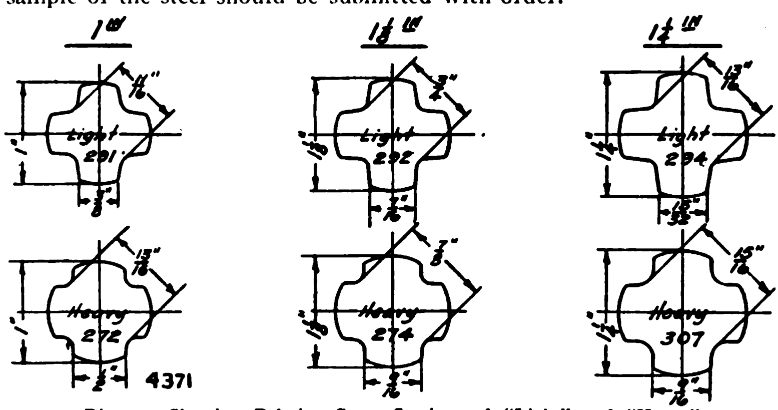


Diagram Showing Relative Cross Sections of "Light" and "Heavy" Cruciform Steels in Three Standard Sizes

HEAVY CRUCIFORM HAMMER DRILL STEELS

All the steels here listed are SOLID steels, for UP holes only, with 4-POINT CROSS bits and WITHOUT SHANK AND COLLAR

Heavy 1-In., for MA, MB / HA, HB Drills Sec. 272

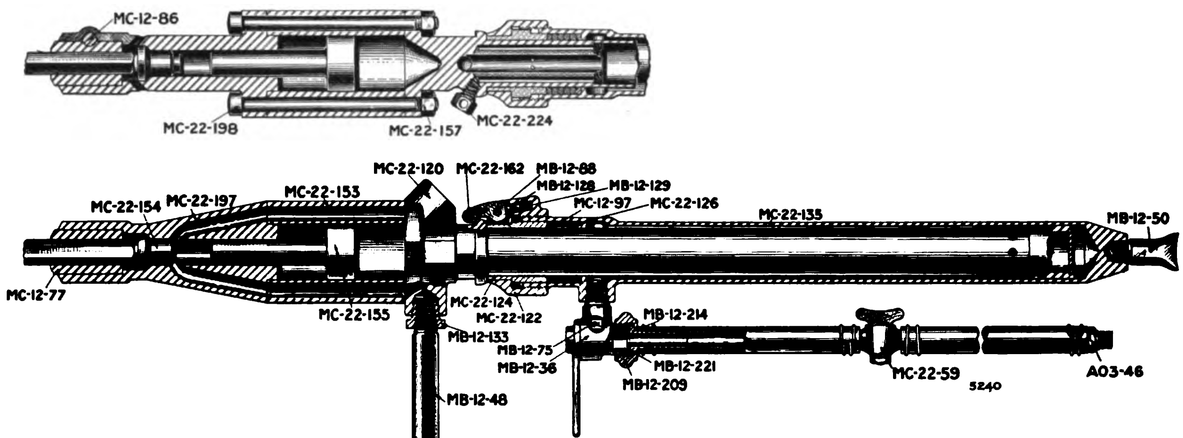
Drilling Length Exclusive of Length in Chuck, Inches	Diam. of Bit Inches	Approx. Weight Per Steel, Lbs.	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set
Standard 6-in. Run					
6	1 3/4	2 1/2	$0.90		Volemilca
12	1 11/16	3 3/4	1.00	$1.90	Volemile
18	1 5/8	5	1.10	3.00	Volemilega
24	1 9/16	6 1/4	1.20	4.20	Volemilejo
30	1 1/2	7 1/2	1.30	5.50	Volemilete
36	1 7/16	8 3/4	1.40	6.90	Volemilhao
42	1 3/8	10	1.50	8.40	Volemilhem
48	1 5/16	11 1/4	1.60	10.00	Volemiliam
54	1 1/4	12 1/2	1.70	11.70	Volemilid
60	1 3/16	13 3/4	1.80	13.50	Volemilimo
Standard 12-in. Run					
12	1 11/16	3 3/4	1.00		Volemillez
24	1 9/16	6 1/4	1.20	2.20	Volemillis
36	1 7/16	8 3/4	1.40	3.60	Volemillum
48	1 5/16	11 1/4	1.60	5.20	Volemilogo
60	1 3/16	12 3/4	1.80	7.00	Volemilos

Heavy 1 1/8-In., for MB, MC / HB, HC Drills Sec. 274

Drilling Length Exclusive of Length in Chuck, Inches	Diam. of Bit, Inches	Approx. Weight Per Steel, Lbs.	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set
Standard 6-in. Run					
6	2	3 1/8	$1.00		Volemimago
12	1 15/16	4 5/8	1.15	$2.15	Volemimeca
18	1 7/8	6 1/4	1.30	3.45	Volemiment
24	1 13/16	7 7/8	1.45	4.90	Volemimes
30	1 3/4	9 3/8	1.60	6.50	Volemimian
36	1 11/16	11	1.75	8.25	Volemimila
42	1 5/8	12 1/2	1.90	10.15	Volemimor
48	1 9/16	14	2.00	12.15	Volemimuda
54	1 1/2	15 5/8	2.10	14.25	Voleminae
60	1 7/16	17 1/8	2.20	16.45	Volemincor
Standard 12-in. Run					
12	1 15/16	4 5/8	1.15		Voleminelo
24	1 13/16	7 7/8	1.45	2.60	Voleminer
36	1 11/16	11	1.75	4.35	Volemineta
48	1 9/16	14	2.00	6.35	Volemingai
60	1 7/16	17 1/8	2.20	8.55	Volemingo

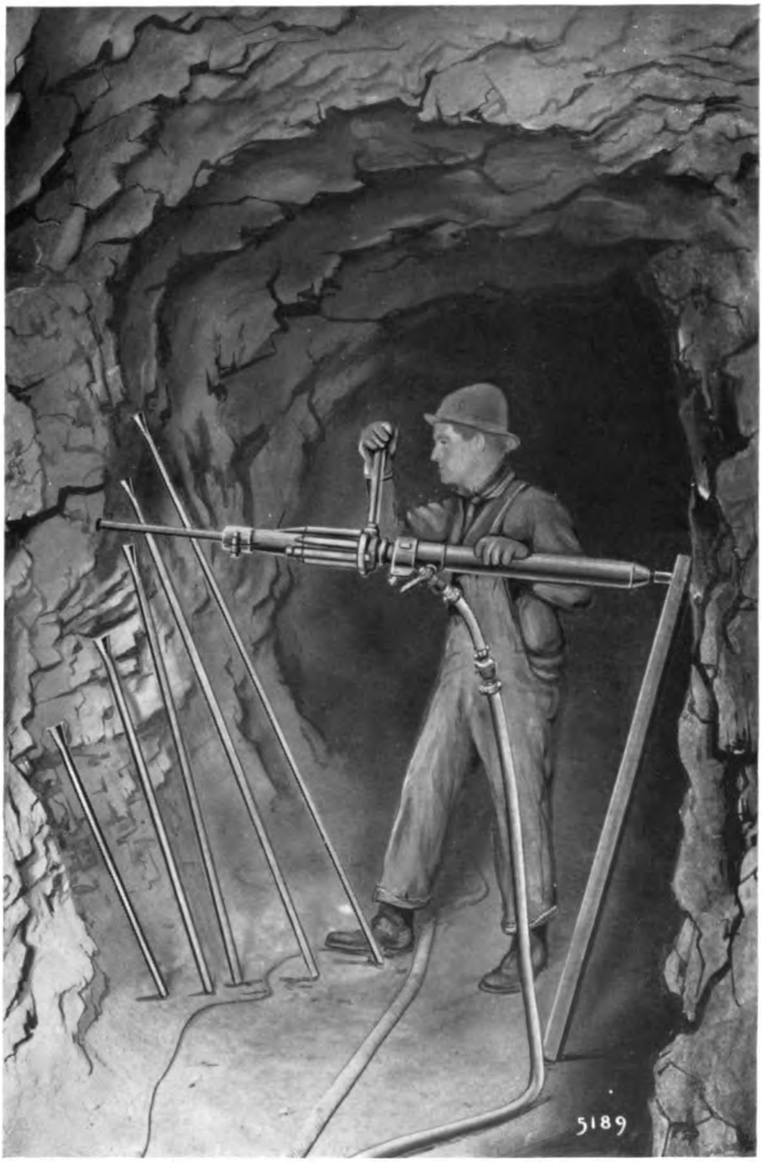
Heavy 1 1/4-In., for MC / HC Drills Sec. 307

Drilling Length Exclusive of Length in Chuck, Inches	Diam. of Bit, Inches	Approx. Weight Per Steel, Lbs.	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set
Standard 6-in. Run					
6	2 1/8	3 1/2	$1.05		Voleminhos
12	2 1/16	5 1/4	1.25	$2.30	Volemini
18	2	7	1.45	3.75	Voleminien
24	1 15/16	8 3/4	1.60	5.35	Voleminina
30	1 7/8	10 1/2	1.75	7.10	Voleminize
36	1 13/16	12 1/4	1.90	9.00	Voleminoid
42	1 3/4	14	2.05	11.05	Voleminola
48	1 11/16	15 3/4	2.20	13.25	Voleminoso
54	1 5/8	17 1/2	2.35	15.60	Volemio
60	1 9/16	19 1/4	2.50	18.10	Volemiogmo
Standard 12-in. Run					
12	2 1/16	5 1/4	1.25		Volemionar
24	1 15/16	8 3/4	1.60	2.85	Volemionda
36	1 13/16	12 1/4	1.90	4.75	Volemionem
48	1 11/16	15 3/4	2.20	6.95	Volemionne
60	1 9/16	19 1/4	2.50	9.45	Volemions



Section of "MC-22" Hammer Drill and Duplicate Part List

MC-22-197	Front Cylinder	MC-22-120	Inner Tube	MC-22-135	Outer Tube
MC-22-153	Back Cylinder	MC-22-122	Packing Nut	MB-12-50	Spud
MC-12-77	1⅛" Light Section Cruciform Nozzle	MC-22-124	Packing Gland	MB-12-36	Throttle Valve (complete)
		MC-22-126	Packing Ring		
MC-22-154	Anvil Block	MC-12-97	Pack'g H'd Pack'g	MB-12-209	Hose Nut
MC-22-155	Piston	MC-22-162	Air Feed Lock	MB-12-214	Hose Nipple
MC-22-198	Side Rods	MB-12-88	Air Feed Lock Pin	MB-12-221	Leather Washer
MC-12-86	Barrel Bolt	MB-12-128	Feed Lock Latch Pin	MB-12-75	Oil Hole Plug
MC-22-157	Side Rod Nuts—Barrel Bolt Nut			MC-22-59	Stop Cock
		MB-12-129	Feed Lock Latch Pin Spring	AO-3-46	Hose Nipple
MB-12-48	Rotating Handle			MC-22-27	Wrench
MB-12-133	Rotating Handle Bushing	MC-22-224	Oil Hole Plug		



The "MC-22" Hammer Drill Drifting in a Mine

The MASON-HENRY Press
Syracuse and New York

TYPE "BC-11" HAMMER DRILL.

BUTTERFLY
VALVE

INGERSOLL-RAND COMPANY

Form No. 4011 11 BROADWAY, NEW YORK January, 1911

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PRODUCTS

Air Compressors
Air Hoists
Air Lift Pumping Systems
"Calyx" Core Drills
Channelers, Stone
"Electric-Air" Rock Drills
"Electric-Air" Stone Channelers
Hammer Drills
Pneumatic Tools
"Radialaxe" Coal Shearer and Under Cutter
Reheaters
Rock Drills
Sand Rammers, Pneumatic
Submarine Drills

Raising with "BC-11" Hammer Drill

General Description

Piston diameter	2"
Piston stroke	4"
Length of feed	22"
Length of machine over all (closed)	52½"
Length of machine over all (extended)	74½"
Weight	69 lbs.
Size air hose	½"

Front head broached to fit any steel specified by customer.

One wrench fits all nuts.

Equipment

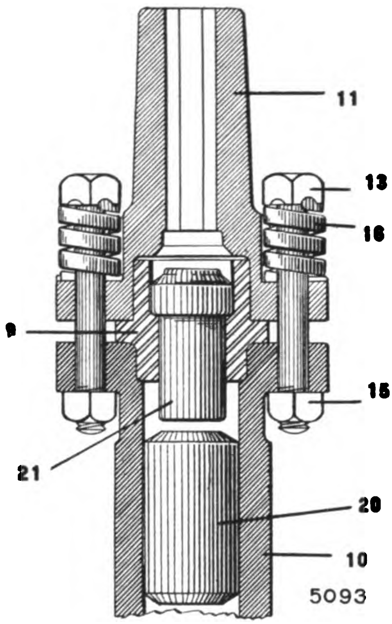
Each telescope feed hammer drill outfit is understood to include a complete drill with telescope feed, together with such fittings as may properly go with the machine in the way of valves, handles, hose connections, the necessary wrenches, etc. Hose, mounting and steels, however, are not included as a part of the regular machine outfit.

Prominent Features

The Butterfly valve hammer drill embodies a number of desirable features, prominent among which are the following:—

Unequalled lasting qualities
Positiveness and simplicity of valve action
Ease of rotation
Simplicity of construction
Single throttle control
Accessibility
Automatic lubrication
Single exhaust
Spring retained chuck
Renewable anvil block or tappet bearing
Non freezing valve motion
High efficiency
No small ports to clog
All wearing parts hardened and ground
No mounting required

Front Head or Chuck Construction



Cylinder, part 10, is fitted with a bushing, part 9, which carries the anvil block, part 21. This arrangement obviates replacing the entire cylinder when the anvil block bearing becomes worn, as was necessary in former constructions. The bushing is made of a superior quality of hardened steel and is easily replaced when, after long usage, it becomes worn.

Front head, part 11, is spring retained and the parts are so designed and arranged that when the steel is out of the machine, the blows of the piston will be taken up by the front head and its springs and not on a shoulder inside of the cylinder. Front head will be broached to fit any shape or size steel specified by customer.

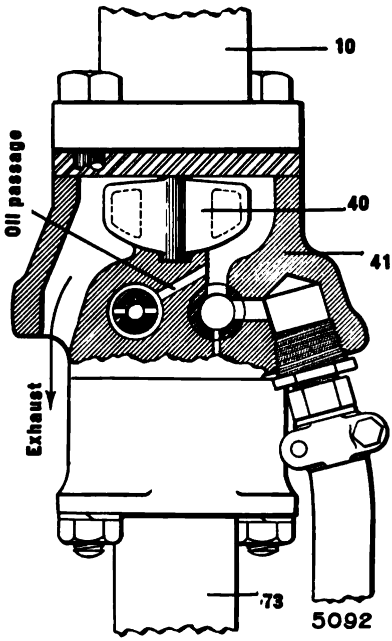
The piston, part 20, has no grooves or weak projections and both ends being the same it cannot be put in the cylinder wrong.

The material and method of treatment used in anvil block, Part 21, is the result of exhaustive tests and years of experience in making similar pieces. The block is superior to other tappets now in use.

Holes are provided in front of the tappet to permit the escape of any dirt or cuttings which enter the chuck around the drill shank.

The cushion springs are designed to lock the front head bolts thus doing away with cotter pins or lock nuts.

Valve and Chest Contruction

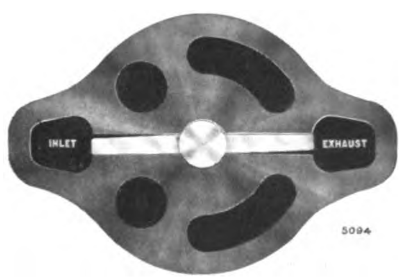


The Butterfly valve. part 40, consists of two wings and a central stem on which it oscillates. One wing controls the supply to each end of the cylinder, the other wing controlling the exhaust from the alternating ends. As the two wings are of the same area, the pressure holding the supply wing on its seat is equalled by the pressure tending to force the exhaust wing off its seat, thus making a balanced valve which requires very little pressure to shift it.

The valve closes the ports by advancing to the seat, not by sliding on the seat, thus making a better fit the longer it runs.

Valve chest, part 41, is arranged to carry the throttle valve and rotation handle. Inlet connection is so made that hose hangs close to feed cylinder.

All exhaust is at one point and directed back parallel to feed cylinder, minimizing tendency to scatter dust.

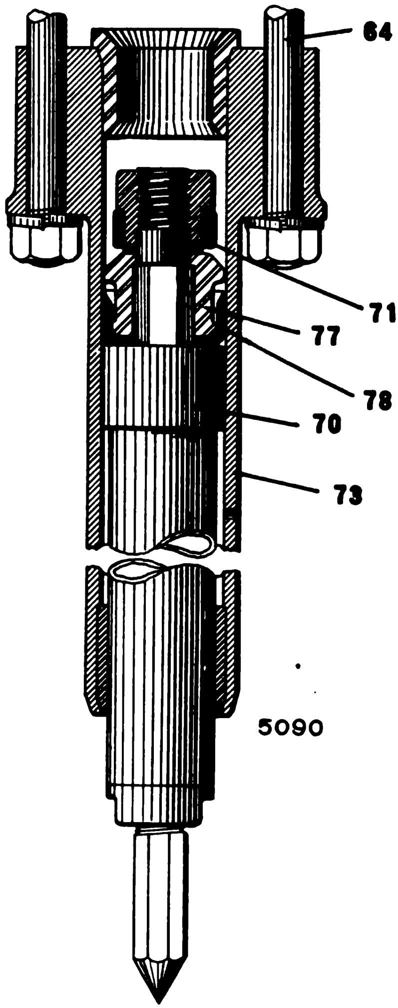


The valve is a single piece of forged steel and is indestructable

The valve chest is located between the hammer cylinder, part 10, and the air feed cylinder, part 73. All parts being held together by two bolts, no threaded joints being used.

Oil is fed from the oiler, directly to the supply side of the valve as shown.

Air Feed Construction



The air feed consists of two members, the air feed cylinder, part 73, and the feed piston, part 70. The feed cylinder is made up of a piece of special steel tubing to which a flange is permantly attached. These pieces will not be furnished separately.

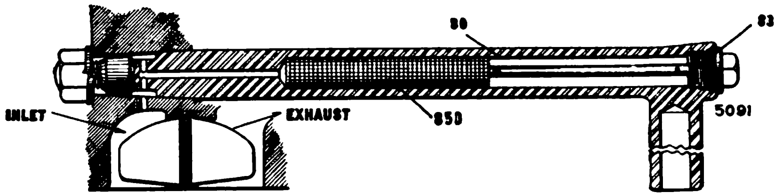
The feed piston is fitted with a cup leather, part 78, which is held in place by a washer, part 77. This leather has been made deeper than in former machines and more chance is given the air to get inside of it to force it out against the walls of the cylinder.

When the air piston is run in, it is automatically retained by a friction spring, part 71.

When necessary to renew the cup leather, the side bolts, part 64, are removed and the feed piston drawn out through the inner end of the feed cylinder. There are no threaded joints on the feed cylinder or feed piston to give trouble and no clamps are needed to hold it together.

The length of feed is 22 in. and the plain type of feed only will be used. No adjustable extension will be furnished.

Rotating Handle and Oiling Device



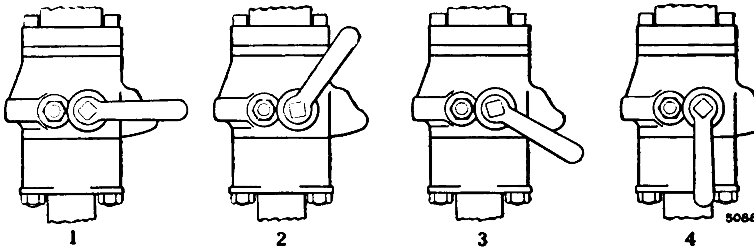
The rotating handle has a taper on one end by means of which it is attached to the valve chest. This does away with threaded connections heretofore used and which have been a great source of trouble in keeping handles tight.

An automatic oiling device is located in the rotating handle of all hammer drills of this type. This consists of a hollow handle, part 80, fitted in a taper hole in the valve chest. The bore in the handle is in direct communication with the supply side of the valve chest as shown. Located in the handle is a porous plug, part 850, beyond which is an oil chamber. Before starting the machine, oil plug, part 83, should be removed and the chamber in the handle filled with light oil. As the machine runs, the pulsations of the air in the supply chamber of the chest draws the oil through the porous plug into the machine. Means are provided to exhaust any pressure in the handle after the air is shut off without drawing all of the oil out of the chamber.

The porous plug serves a double purpose of regulating the flow of oil and cleansing it of any grit or dirt it may contain. Oil chamber in the handle should be filled before starting each shift.

Light machine oil is good to use but our special brand of Vacuum Arctic Ammonia Oil is better. Do not use thick oil as it will cause the parts to work sluggishly.

Operation of Throttle Valve



No. 1. In this position throttle valve is closed, air being shut off from the hammer and the feed.

No. 2. Position for starting a hole, giving light feed pressure and moderate drilling speed; a feature not found in any other machine. This is not the full running position.

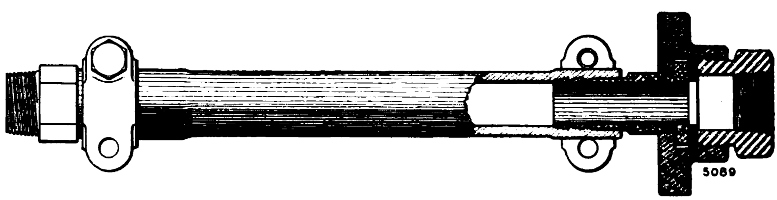
No. 3. Full pressure is on the feed, but hammer is not running. Used in "pointing" a hole.

No. 4. Full running position, maximum pressure on the feed and full drilling speed.

Inlet Connection

Each hammer drill is equipped with an inlet connection as shown in the sketch. This consists of a short section of hose having a nipple in one end which screws into the inlet in the valve chest. The other end carries an improved H D coupling complete.

This coupling is made up of three pieces; a hose stem, a nut, and a spud which is tapped for a standard pipe connec-



tion. The parts are secured in the hose by drop forged clamps.

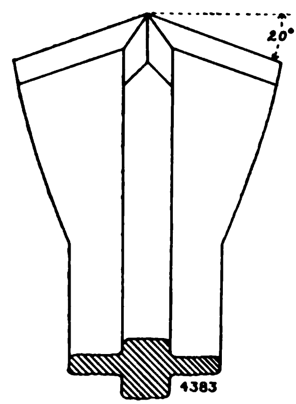
This form of connection has been found to give much better satisfaction than those previously used as it makes coupling up easy and quick, overcoming twisting of the hose.

Air Supply Hose

Name	WEIGHT, LBS. Unboxed	WEIGHT, LBS. Boxed	Telegraph Name	List Price	Price Per Foot
50-foot Length PLAIN ½-inch 7-ply "Antipeel" Hose, with Couplings	17	37	VOLEMIORA	$11.75	$0.20
50-foot Length WIRE-WOUND ½-inch 7-ply "Antipeel" Hose, with Couplings	26	46	VOLEMIORBS	12.75	0.22
50-foot Length PLAIN ¾-inch 7-ply "Antipeel" Hose, with couplings	29	50	VOLEMIOSAE	14.00	0.24
50-foot Length WIRE-WOUND ¾-inch 7-ply "Antipeel" Hose, with Couplings	39	60	VOLEMIOSCA	15.00	0.26

Size and Style of Bit

Experience has demonstrated that in hammer drill work a bit with a high center gives the best result; and the steels listed on page 10 are furnished with the bit "crowned" as indicated in the sketch.

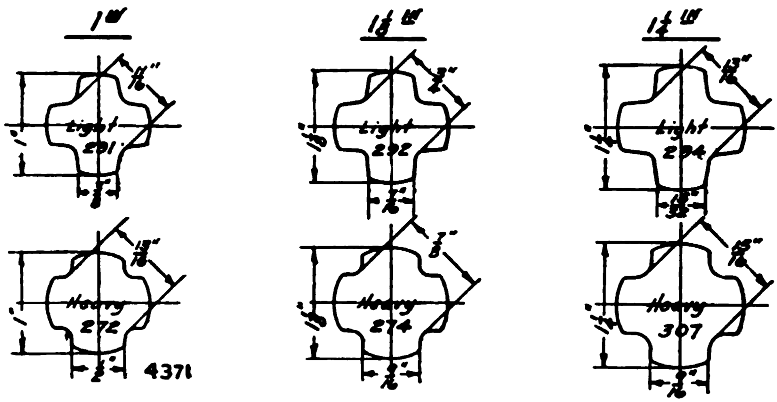


A "crowned" hammer drill steel bit

The Company recommends the use of large bits and heavy steels, as giving more satisfactory drilling results and better breaking of the ground. A hole bottomed to take 1¼-inch powder will evidently break more rock than one bottomed for 1-inch powder. Probably five or six holes bottomed for the larger powder will break as much ore as eight or nine holes bottomed for only 1-inch powder. This means less proportionate drilling time for a given amount of breaking, with greater headway made, less steels to sharpen and transport. Rotation is also made easier where a large bit is used.

This general statement, while true so far as large stopes and large raises are concerned, must be qualified where narrow veins are to be followed or where the ground is such that heavy charges would pulverize the ore or shatter the walls. In the latter case smaller holes will serve and a smaller steel and bit may be used.

Steel Sections



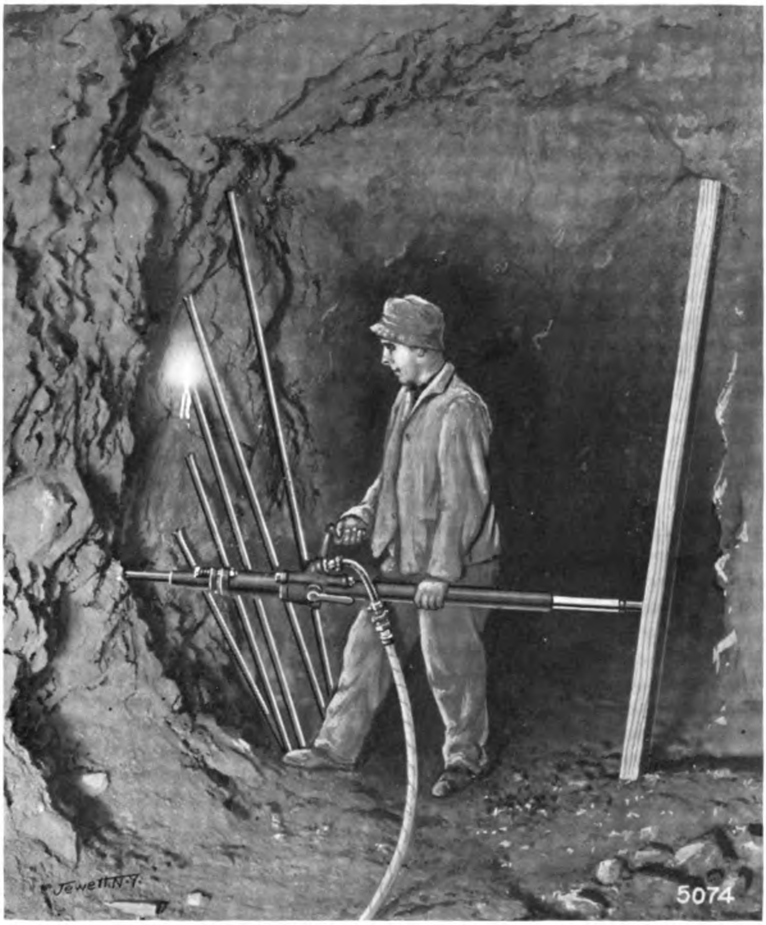
The cut shows standard sections of cruciform steel. Squares or hexagons can also be furnished. The size to be used should be specified when ordering drills. Front heads will be made for any section of steel. When special sections are wanted a sample of the steel should be submitted with order. The Butterfly Hammer Drill does not require shanking of the steel.

HEAVY CRUCIFORM HAMMER DRILL STEELS

All the Steels here listed are SOLID Steels, with FOUR-POINT CROSS Bits

Drilling Length, Exclusive of Length of Chuck, Inches	Diameter of Bit, Inches	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set	Diameter of Bit, Inches	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set	Diameter of Bit, Inches	List Price Per Single Steel	List Price Per Set	Telegraph Name of Set
Stan'rd Run	Heavy 1-in.—Section 272				Heavy 1⅛-in.—Section 274				Heavy 1¼-in.—Section 307			
12	$1\frac{11}{16}$	$1.00		Volemillez	$1\frac{15}{16}$	$1.15		Voleminelo	$2\frac{1}{16}$	$1.25		Volemionar
24	$1\frac{9}{16}$	1.20	$2.20	Volemillis	$1\frac{13}{16}$	1.45	$2.60	Voleminer	$1\frac{15}{16}$	1.60	$2.85	Volemionda
36	$1\frac{7}{16}$	1.40	3.60	Volemillum	$1\frac{11}{16}$	1.75	4.35	Volemineta	$1\frac{13}{16}$	1.90	4.75	Volemionem
48	$1\frac{5}{16}$	1.60	5.20	Volemilogo	$1\frac{9}{16}$	2.00	6.35	Volemingai	$1\frac{11}{16}$	2.20	6.95	Volemionne
60	$1\frac{3}{16}$	1.80	7.00	Volemilos	$1\frac{7}{16}$	2.20	6 55	Volemingo	$1\frac{9}{16}$	2.50	9.45	Volemions
72	$1\frac{1}{16}$	2.00	9.00	Volemilyba	$1\frac{5}{16}$	2.40	10.95	Volemingue	$1\frac{7}{16}$	2.90	12.25	Volemiopea

Sets having 6-inch run furnished when required.



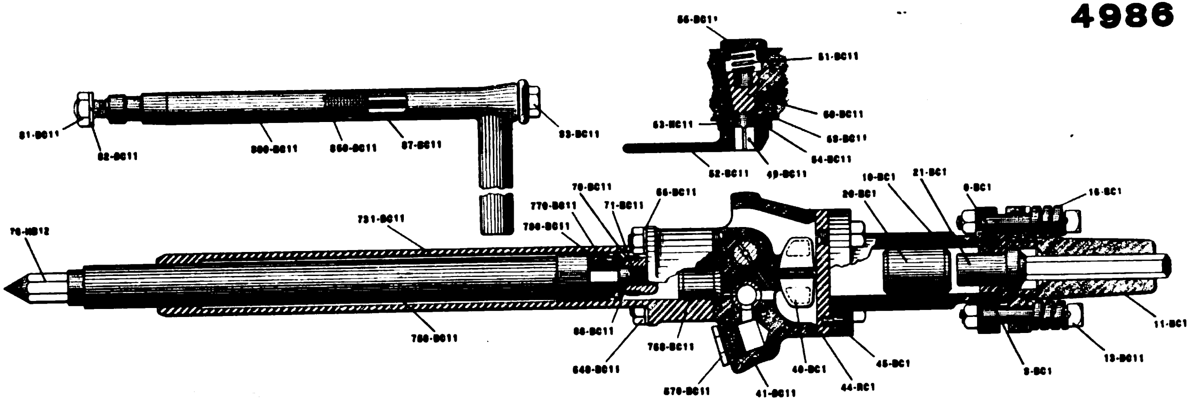
Drifting with "BC-11" Hammer Drill

For this work different methods may be used for removing the cuttings from the hole:—

FIRST: By means of air from the machine through hollow tappet or steel.

SECOND: By means of an air or water jet fed into the hole through a $\frac{1}{8}$ inch iron pipe. Solid steel being used.

4986



10-BC1	CYLINDER	50-BC11	THROTTLE VALVE	780-BC11	FEED PACKING LEATHER
9-BC1	CYLINDER BUSHING	51-BC11	THROTTLE VALVE SPRING	79-BC11	FEED PISTON NUT
8-BC1	CYLINDER BUSHING PIN	52-BC11	THROTTLE LEVER	86-BC11	FEED PISTON NUT LOCK WASHER
11-BC1	FRONT HEAD	53-BC11	THROTTLE LEVER STOP PIN	731-BC11	FEED CYLINDER
13-BC11	FRONT HEAD BOLT AND NUT	54-BC11	THROTTLE LEVER RATCHET PIN	640-BC11	FEED CYLINDER BOLT AND NUT
16-BC1	FRONT HEAD SPRING	55-BC11	SCREW PLUG	66-BC11	FEED CYLINDER BOLT LOCK WASHER
20-BC1	PISTON	56-BC11	THROTTLE LEVER RATCHET PIN SPRING	760-BC11	FEED CYLINDER BUSHING
21-BC1	ANVIL BLOCK	49-BC11	THROTTLE LEVER PIN	800-BC11	ROTATING HANDLE
40-BC1	VALVE	670-BC11	NIPPLE	81-BC11	ROTATING HANDLE NUT
41-BC11	VALVE CHEST	700-BC11	FEED PISTON ROD	82-BC11	ROTATING HANDLE LOCK WASHER
44-BC1	VALVE CHEST COVER	71-BC11	FEED PISTON RETAINING SPRING	83-BC11	ROTATING HANDLE PLUG
45-BC1	VALVE CHEST COVER DOWEL	70-HB12	TAIL PIECE	850-BC11	OILER
		770-BC11	FEED PACKING WASHER	87-BC11	OILER RETAINING TUBE

HAMMER DRILL

TYPE "BC 11"

INGERSOLL-RAND CO.

NEW YORK LONDON

0111

4-10

"HORNET"

(CROWN "HA-13")

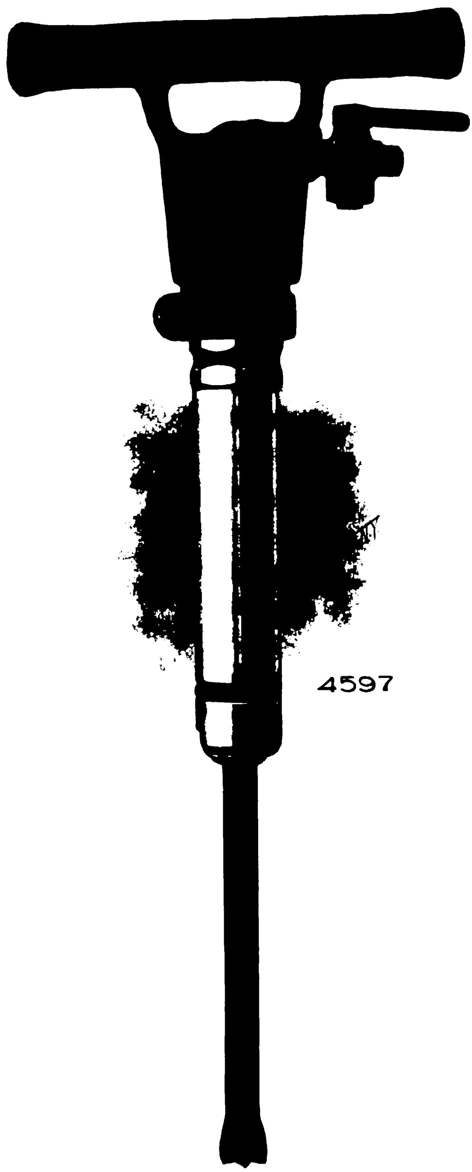
HAND HAMMER DRILL

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Form No. 4014 January, 1911

Drilling with the "Hornet" Hand Hammer Drill



Standard "Hornet" Hand Hammer Drill ("Crown HA-13")

THE "Hornet" Hand Hammer Drill is one of the standard line of Ingersoll-Rand "Crown" hammer drills, with symbol "HA-13." It is intended for somewhat heavier duty than the "Wasp" ("Crown HA-14") plug drill, being adapted for holes up to 48 inches in depth, with bottom diameter of 1 to 1½ inches. It is fitted with a hollow anvil block and removable bushing, for use with hollow steels, a part of the exhaust passing through the steel and blowing the face clean under the bit. But it can be fitted with a solid anvil block for use with solid steels without shank and collar.

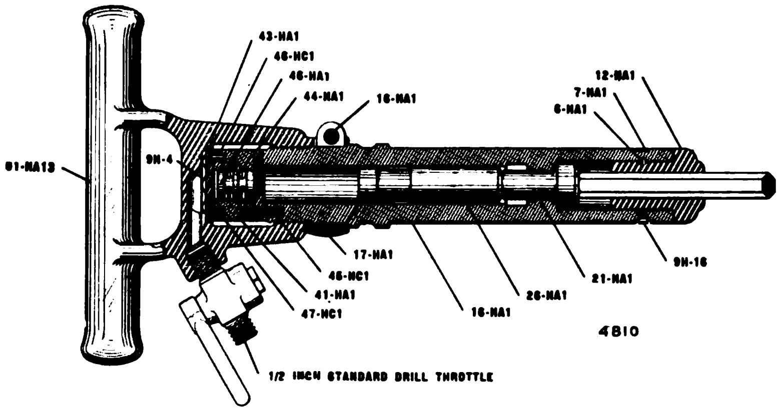
The handle is of a special improved type, giving either the usual spade grip in the middle or two grips well separated at the ends for easy rotation. Air admission is at the side of the head-block and a standard ½-inch drill throttle valve is screwed in at this point.

The "Hornet" has the latest type of "Crown" valve. The cylinder is of special steel, hardened and ground in the bore. The piston or hammer is of hardened steel, as well as all other wearing parts. The best materials are used throughout, and the workmanship cannot be surpassed. The tool is one of large capacity, utmost convenience and splendid wearing qualities. The specifications of the "Hornet" are given below.

Cylinder Diameter	1⅜ inches
Stroke	3¼ inches
Length over all	21 inches
Size of Air Inlet	½ inch
Weight	40 lbs.

Water-displacement meter tests of this tool show the following air consumptions:

Air Pressure	Cu. Ft. Free Air Per Min.
40 lbs.	12
50 lbs.	18
60 lbs.	22
70 lbs.	26
80 lbs.	30
90 lbs.	35
100 lbs.	40



Duplicate Part List

01-HA13	Handle	20-HA1	Piston
9H-4	Inlet Screen	21-HA1	Anvil Block
10-HA1	Cylinder	41-HA1	Valve Box
6-HA1	Cylinder Bushing Pin	40-HA1	Valve
7-HA1	Cylinder Bushing Pin Spring	43-HA1	Valve Box Top Cap
12-HA1	Cylinder Bushing	44-HA1	Valve Box Bottom Cap
9H-16	Cylinder Plug	45-HC1	Valve Box Bottom Dowel
17-HA1	Cylinder Clamp	46-HC1	Valve Box Cap Dowel
18-HA1	Cylinder Clamp Bolt	47-HC1	Valve Box Top Dowel
19-HA1	Cylinder Clamp Bolt Washer		

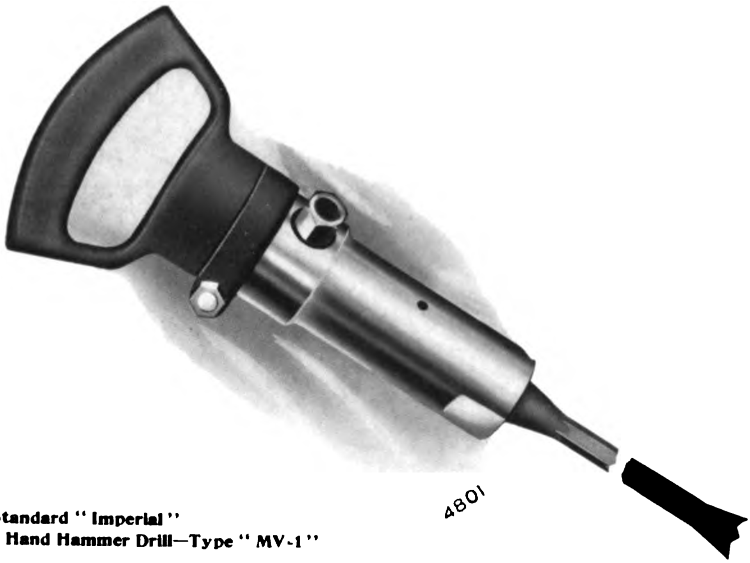
"IMPERIAL" HAND HAMMER DRILLS

TYPES "MV-1" AND "MV-2"

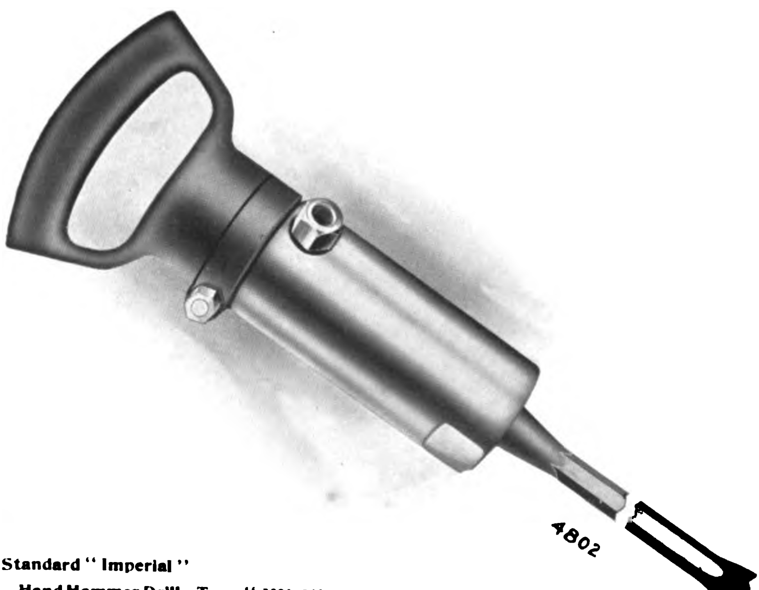
INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 4015 — January, 1911

Putting in a Down Hole in a Block with the "Imperial" Hand Hammer Drill



Standard "Imperial"
Hand Hammer Drill—Type "MV-1"



Standard "Imperial"
Hand Hammer Drill—Type "MV-2"

THE "Imperial" Hand Hammer Drills, Types "MV-1" and "MV-2," are valveless tools, having but one moving part—the piston or hammer—which itself performs the function of a valve in controlling the admission and exhaust of air. These two drills are identical in the dimensions of their working parts and differ only in weight, so that one description will cover both.

The "MV-1" and "MV-2" are intended for drilling holes up to 48 inches in depth, bottoming at from 1 to 1 1-2-inch diameter. They use hollow steels with a collar and hexagon shank 7-8 x 3 inches. A portion of the exhaust escaping through the steel blows the dust from before the bit, clearing the face. Air admission is at the side of the barrel. A large spade handle is used, screwed on the barrel and locked by a handle nut.

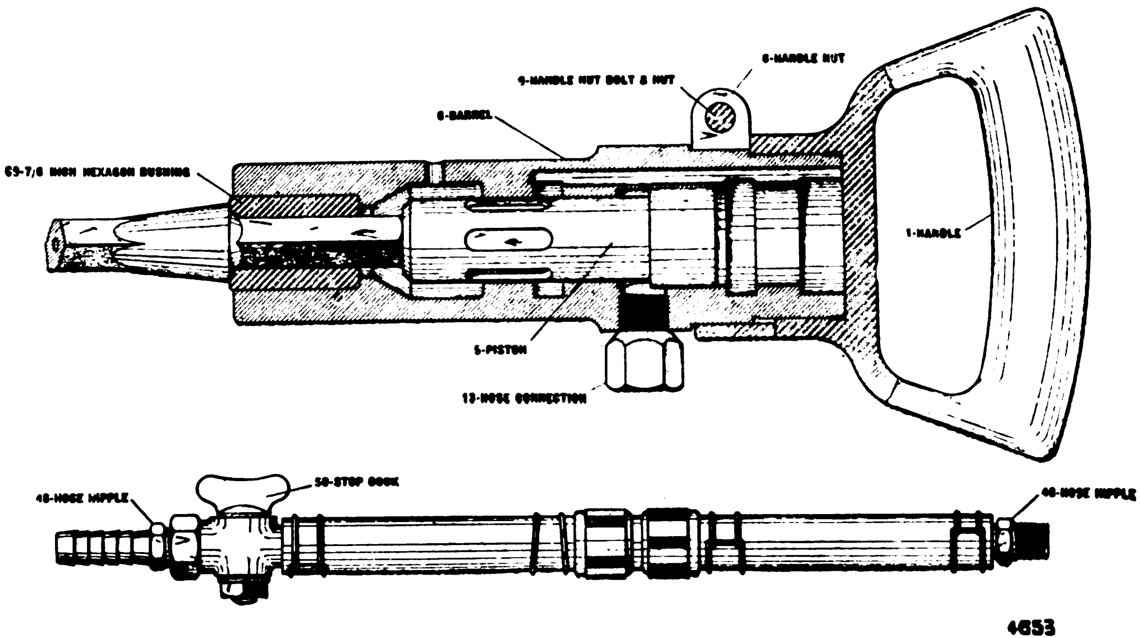
A short length of hose goes with each tool, carrying a stopcock or throttle valve. The best of materials are used throughout, the wearing parts being of hardened and ground steel.

The "MV-2" drill is eight pounds heavier than the "MV-1," this increase being secured by enlarging the barrel. The object of this is to meet the demands of those who want a heavier tool, giving greater weight on the bit in down holes without manual pressure. The specifications of these two tools are as follows:

SYMBOL	"IMPERIAL MV-1"	"IMPERIAL MV-2"
Cylinder Diameter, inches	$1\frac{7}{16}$ and $1\frac{11}{16}$	$1\frac{7}{16}$ and $1\frac{11}{16}$
Stroke, inches	$2\frac{1}{4}$	$2\frac{1}{4}$
Length over all, inches	15	15
Size of Air Inlet, inches	$\frac{3}{8}$	$\frac{3}{8}$
Weight, lbs.	22	30

The following air consumptions have been recorded for these tools under water-displacement meter test:

AIR PRESSURE	CU. FT. FREE AIR PER MIN.
60	12
70	15
80	19
90	23
100	27



1—MV-1	Handle	6—MV-2	Barrel	46—A-1	Hose Connection
5—MV-1	Piston	8—MV-1	Handle Clamp	59—MV-1	Stop Cock
6—MV-1	Barrel	9—B-1	Handle Clamp Bolt and Nut	69—MV-1	Hexagon Cylinder Bushing
		13—MV-1	Hose Connection		

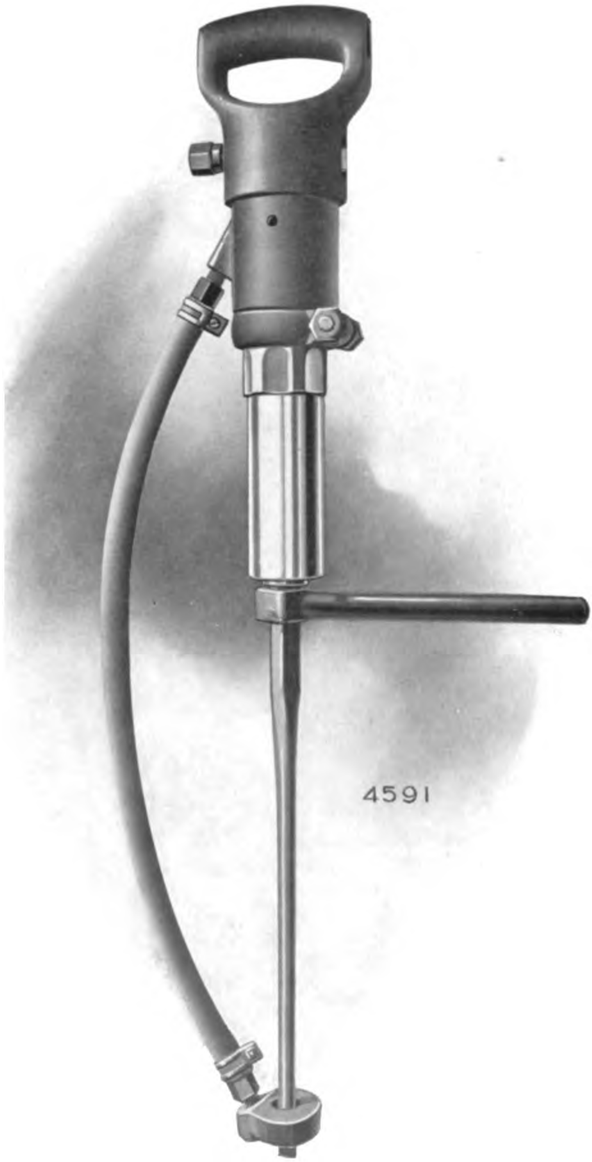
Section of "Imperial" Hand Hammer Drill (Types "MV-1" and "MV-2") with Duplicate Part List

"WASP"
(CROWN "HA-14")
PLUG DRILL

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 4013 January, 1911

Drilling a Plug Hole with the "Wasp" Plug Drill



The "Wasp" Plug Drill (Crown HA-14) Complete

THE "WASP" PLUG DRILL

"CROWN HA-14"

THE "Wasp" Plug Drill is one of the standard line of Ingersoll-Rand "Crown" hammer drills and is designed for the lightest plug drilling work, being recommended only for ⅝ to ⅞-inch holes, three to six inches deep. For this class of work it uses standard plug drill steels, with shanks 11/16 inch diameter by 2⅝ inches long.

This is a push-handle type, in which pressure on the handle opens the throttle and admits air. When the handle is drawn back to withdraw the steel from the hole, the air is automatically shut off. A short length of hose leads a portion of the exhaust air to a dust-collar resting around the steel at the mouth of the hole; and this exhaust jet blows the hole free from dust and cuttings. Air admission is at the side of the head-block. The steel is rotated by means of a handle which fits the square of the steel.

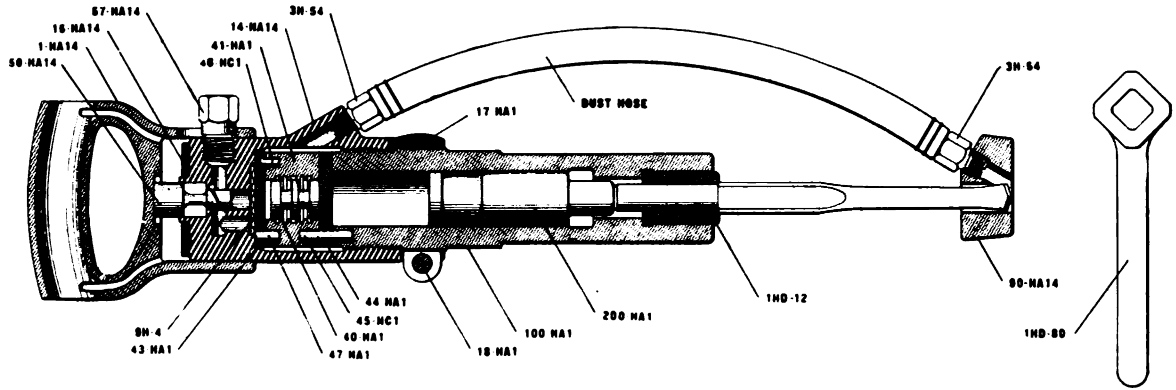
The "Wasp" has the latest form of "Crown" valve, travelling lengthwise of the drill. The cylinder is of special steel, hardened and ground in the bore. The piston or hammer is of hardened steel. The best materials are used throughout and the workmanship is unsurpassed, the result being a tool of high efficiency and splendid wearing qualities.

The specifications of this tool are as follows:

Cylinder diameter	1⅜ inches
Stroke	2½ inches
Length over all	17½ inches
Size of Air Inlet	⅜ inch
Weight	21 lbs.

The following air consumptions have been recorded by this tool under test by a water-displacement air meter:

Air Pressure	Cu. Ft. Free Air per Min.
40 lbs.	10
50 "	13
60 "	17
70 "	21
80 "	25
90 "	30
100 "	35



4651

1-HA14	Handle	41-HA1	Valve Box
9H-4	Inlet Screen	43-HA1	Valve Box Top Cap
100-HA1	Cylinder	44-HA1	Valve Box Bottom Cap
1HD-12	Cylinder Bushing	45-HC1	Valve Box Bottom Dowel
14-HA14	Head Block	46-HC1	Valve Box Cap Dowel
15-HA14	Head Block Washer	47-HA1	Valve Box Top Dowel
17-HA1	Cylinder Clamp	50-HA14	Throttle Valve
18-HA1	Cylinder Clamp Bolt	57-HA14	Nipple
19-HA1	Cylinder Clamp Bolt Washer	3H-54	Hose Nipple
200-HA1	Piston	1HD-80	Rotating Handle
40-HA1	Valve	90-HA14	Dust Hose Nozzle

Duplicate Part List and Section of "Wasp" Plug Drill ("Crown HA-14")

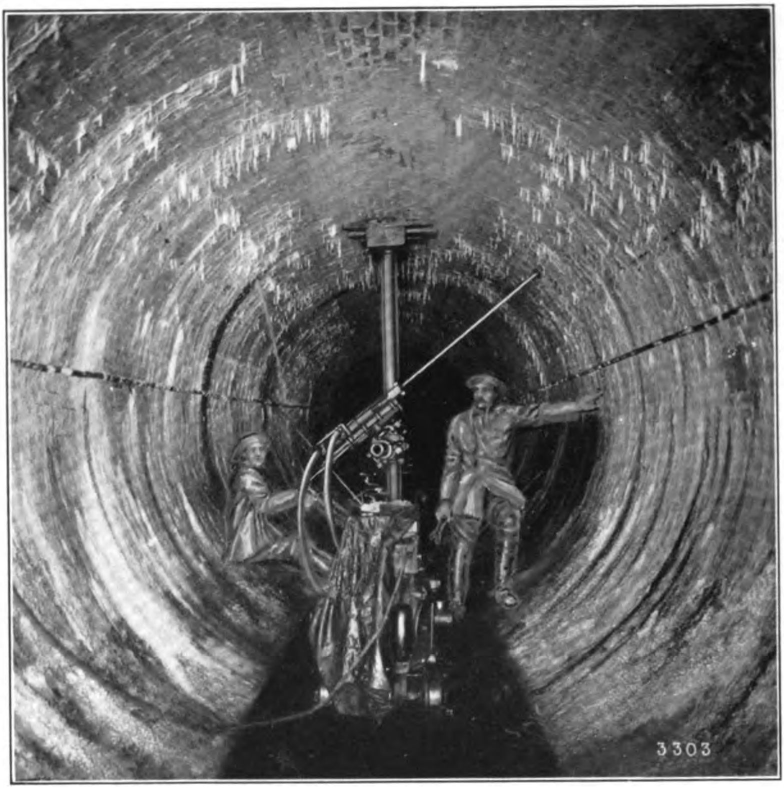
TEMPLE-INGERSOLL
"ELECTRIC-AIR" ROCK DRILLS

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK
Form No. 4109 September, 1910

THE great flexibility and economy of electric transmission systems, and the well-known efficiency of the electric generator and motor, have long maintained an interest in the problem of applying their advantages to rock drilling, even in the face of repeated failure.

Almost numberless attempts along this line have produced the many "electric" drills which have from time to time been exploited with varying, but never satisfactory, results. Economical of power they certainly have been, but when measured by the true standard of sustained economy, involving power and repair costs per foot of hole drilled, day after day and month after month over a long period, their performance has fallen so far behind that of the old reliable air drill that they never secured any foothold in the practical field. They took little power, but they did little work — and they were very costly to keep up.

One of Four "5-C" ELECTRIC-AIR Drills at Work on the Bodensee-Toggenburg Railroad in Switzerland

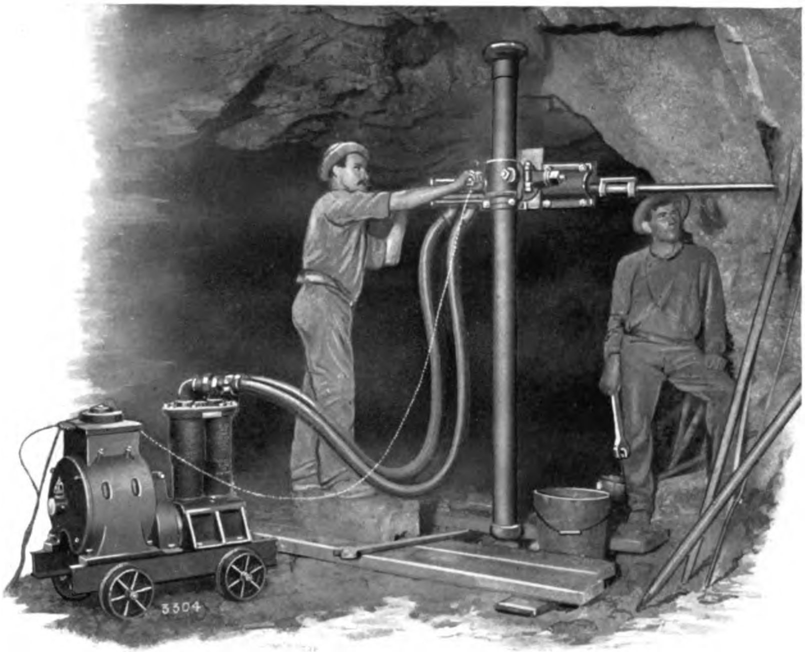


Putting in Test Holes in a Sewer Tunnel

The problem of rock drilling by electric power remained, however, until the Temple-Ingersoll "Electric-Air" Drill was offered to the trade as a complete solution. The fact that this drill makes its appearance with the endorsement of the largest builders of air drills in the world at once stamps it as a practical and reliable device, fully conforming with common-sense rock drill standards.

Not an Experimental Machine

For more than four years the "Electric-Air" Drill has been in successful operation in all classes of rock work and in most of the principal countries in the world. The original drills of this type are still at work in Colorado mines where the machine was introduced and developed. To date (September, 1910) over one thousand of these machines have been sold.



Tunnel Driving with the ELECTRIC-AIR Drill

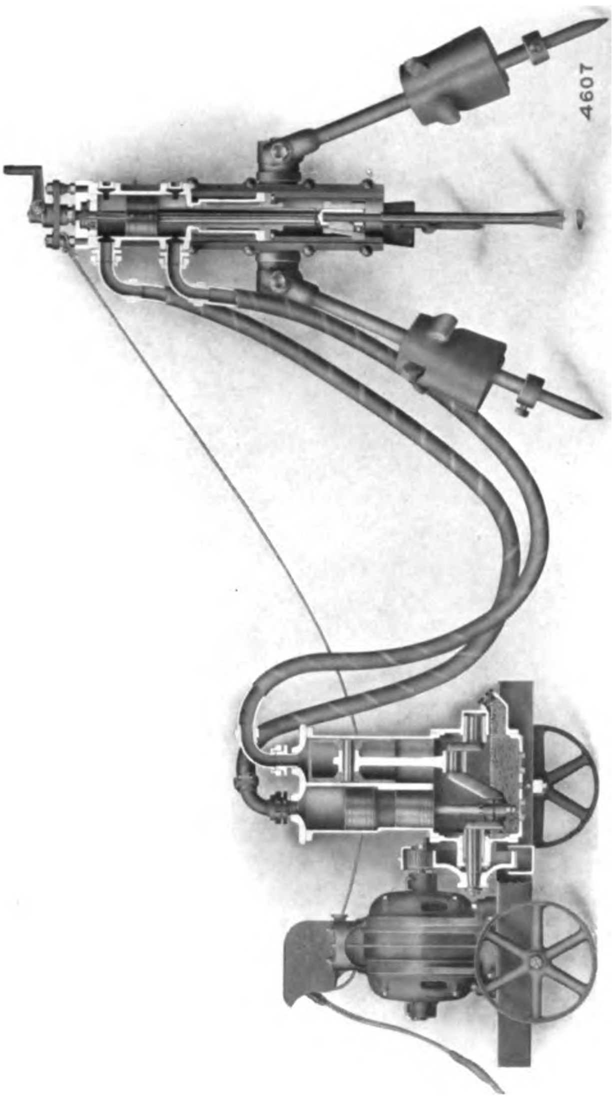
Description

The "Electric-Air" Drill is an air drill driven by pulsations of compressed air created by a duplex air pulsator actuated by a standard electric motor. The air is never exhausted but is simply used over and over again, playing back and forth in a closed circuit.

The drill is the simplest type possible — a cylinder containing a moving piston and rotation device, with no valves, chest, buffers, springs, side rods or pawls. The cylinder is larger but the piston is shorter, making the weight of the drill unit about the same as, or even less than, that of the corresponding air drill.

The pulsator is a vertical duplex single-acting air compressor with opposed cranks, but with no intake or discharge valves or water jackets. It is geared to a motor, either direct or alternating current, and mounted on a wheeled truck for easy handling.

Two short lengths of hose connect pulsator and drill, each running from one pulsator cylinder to one end of the drill cylinder and serving as a port for air admission and return.



Elevation of ELECTRIC-AIR Drill, partly in Section

ELECTRIC-AIR Drill in a Colorado Tunnel

The complete outfit is of the utmost simplicity, giving satisfactory results in the hands of such practical men as are everywhere available on work demanding machine drills.

Why the System is Economical

The ordinary air or steam driven rock drill takes a full cylinder of air or steam at full pressure each stroke, and exhausts or discharges it to atmosphere at practically full pressure. No advantage, therefore, is taken of the expansive properties of the air or steam, representing an amount of power wasted without doing useful work.

The "Electric-Air" Drill operates on an entirely different principle. The closed system is filled with air under a low pressure, which is simply a transmitting agent between the piston of the pulsator and the piston of the drill itself. The object of slightly compressing this air is to give it a greater density for the transmission of the pulsations imparted to it by the pulsator. In fact, the air in the system may be considered as an unwearing, unbreakable spring or cushion between the pulsator and the drill. The pressure in the air simply gives the requisite tension to this spring. Practically

The ELECTRIC-AIR Drill at Work in Close Quarters

the only loss of power is that consumed in overcoming the friction of the mechanism. There may be said to be no loss between the pulsator and drill.

Compensation for Leakage

Some leakage of air from the system is inevitable. This is provided for by a compensating valve on the pulsator which is adjusted to automatically maintain the requisite pressure in the circuit. When pressure falls below this determined limit, due

ELECTRIC-AIR Drill Used for Testing Coal Veins in an Anthracite Mine

to leakage somewhere, this valve automatically opens and admits a small volume of free air which is compressed by a differential area on one of the pulsator pistons until the normal working pressure is restored. But the wearing surfaces throughout the system are so large and the lubrication is so perfect that leakage is very slight, provided the cup leather of the drill is occasionally renewed.

Power Consumption

The 5-C "Electric-Air" Drill uses, under ordinary conditions, about 5 H.P. at the pulsator; the "4-E" uses about 4 H.P.; and the

A "5-C" ELECTRIC-AIR Drill in the Mine of the West Hecla Mining Company Burke, Idaho

"3-C" about 3 H.P. These figures mean nothing unless taken in connection with the fact that the "Electric-Air" Drill, with these motors, does as much work as the equivalent air drill using three or four times the power. Following back throughout the system to the electric generating plant and allowing for all reasonable loss in the electric system, the power required per drill at the power house for the "Electric-Air" Drill is only one-third or one-fourth that which the ordinary rock drill requires. A recent instance showed a power cost per shift for the "Electric-Air" Drill of 62½ cents and in another case the user stated that his power cost was practically negligible.

ELECTRIC-AIR Drill on 10-Foot Muck Pile in Tunnel Heading

Drilling Capacity

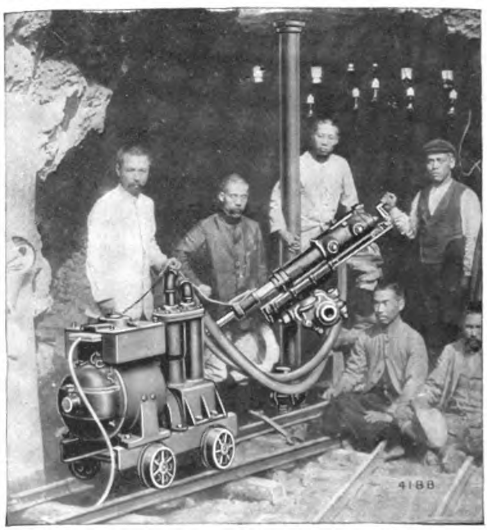
The "Electric-Air" Drill is sold under a guarantee to do as much work as a standard air drill of equivalent rated capacity with 80 pounds air pressure. More specifically, the 5-C "Electric-Air" Drill corresponds in capacity to a standard 3¼-inch air or steam rock drill; the "4-E," to a 3-inch rock drill; and the "3-C," to a standard 2-inch rock drill. This guarantee is all the statement of capacity required by those familiar with the work of rock drills of standard type.

Mudding Quality

A common weakness of all "electric drills has been their short stroke. They consequently would not "mud" well and required frequent changes of steel that the hole might be cleaned. The "Electric-Air" Drill has a stroke equal to, or even greater than, that of the air driven rock drill of corresponding capacity; and the peculiar nature of its return stroke, and the quick, powerful action give splendid "mudding" qualities. The length of stroke is varied simply by cranking forward in the shell; and both stroke and force of blow may be adjusted by the same means for fast drilling under any circumstances. If a hole does "mud up" or form a "mud collar" in bad rock, the machine can be backed out without injury while running, thus clearing itself quickly. Its action covers a range from the shortest stroke and the lightest blow possible with an air drill, up to a long stroke and an unmatched crushing blow.

Pulling-Out Power

When the ordinary rock drill, whether steam or air driven, sticks or "fitchers," it simply pulls back with a steady pressure and the steel must be sledged until it loosens. The "Electric-Air" Drill, on the contrary, when it does momentarily stick, receives on its piston upwards of 400 alternating pulls and pushes per minute; and this repeated pulsation has a tendency to promptly loosen and dislodge the stuck bit, except, of course, where a dull bit has become wedged.



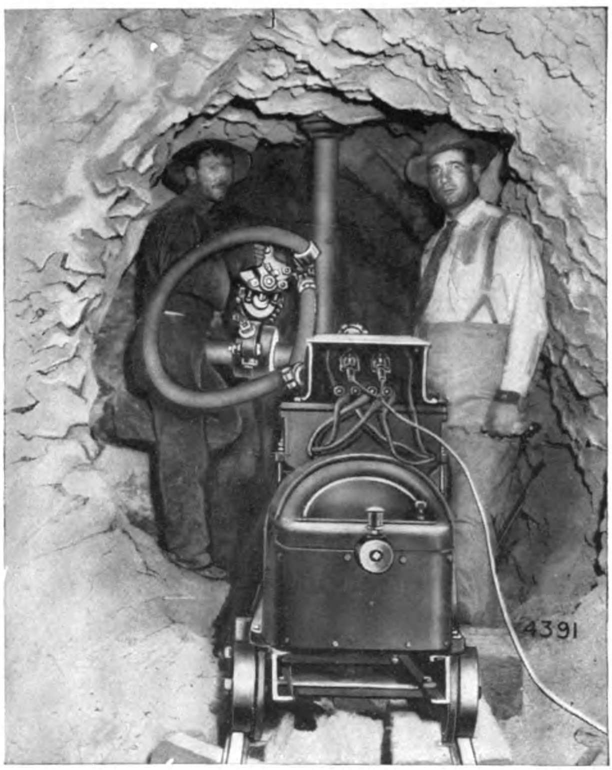
ELECTRIC-AIR Drill in Japan

The Question of Endurance

Every "electric" drill has failed because of the failure of some of its vital and delicate parts to withstand the terrific strains of rock drilling. They have been of two general types; either the motor was on the drill, or it was connected to the drill by a flexible

shaft. In the first case considerations of portability demanded a light and weak construction which would not stand the jar and vibration, while the motor must be small and light, incapable of handling the heavy overload encountered in a bad hole; and the insulation soon gave out under the shock and continuous vibration. In the second case the flexible shaft was a delicate mechanism subject to rapid wear and frequent injury in handling, or by a fall of rock. In both cases cams, springs, belts and other undesirable elements were required and the drill was limited to a short stroke with the consequent drawbacks.

The "Electric-Air" Drill avoids all such difficulties by simply eliminating all delicate parts. Those parts which remain are of the best materials, specially treated by the methods which have made the unmatched endurance records of Ingersoll-Rand rock drills. A standard motor is used, equal to the heaviest momentary overload, and mounted on a truck entirely separate from the drill,



ELECTRIC-AIR Drill in a Mexican Mine

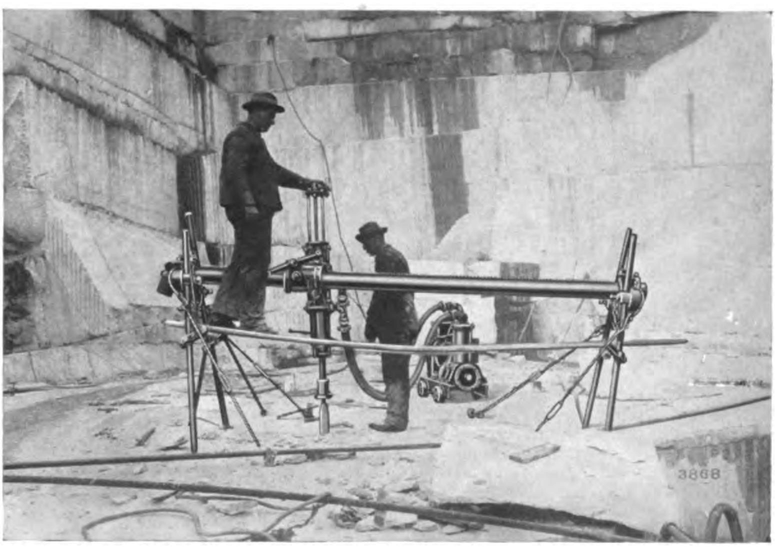
therefore free from vibration and jar. The transmission is by compressed air — cheap and unbreakable — playing back and forth in a closed circuit. Nothing can be simpler than this mechanism throughout.

Perfect Cushioning

In operation the "Electric-Air" Drill has every desirable feature of the most perfect air drill. The cushioning is such that the piston, in running, does not normally strike either front or back head. This makes very easy the problem of handling it in all kinds of drilling. It can be adjusted to strike a terrific blow up to the point of shattering or bending the heavy steels used; or it can be run at full stroke without striking a head, in case a seam or "bug-hole" is encountered. When a hole is to be reamed the motor is thrown on a lower speed; or where single-speed motor is used the drill can be run on a shorter stroke. In backing through a "mud collar," in working through a "pocket," a diagonal seam or a soft spot, or in starting a hole on a glancing surface, the machine approaches in its performance the drill runner's ideal.

Lubrication

The system of lubrication of the "Electric-Air" Drill is automatic and complete, the "splash" method being employed. The closed crank case of the pulsator is partially filled with oil into which the cranks, in their rotation, dip and splash the lubricant



ELECTRIC-AIR Drill on a Quarry Bar Working in Barre Dark Granite

ELECTRIC-AIR Drill Working on a Bench in a Kentucky Limestone Quarry

into the cylinder bores and over all pulsator bearings. While most of this oil drains back to the crank chamber, a portion is atomized and carried through with the air into the drill.

The Field of the "Electric-Air" Drill

The field of the "Electric-Air" Drill, broadly speaking, is the mine, tunnel, quarry, contract, or wherever rock is to be drilled. Whether this machine or the standard air drill should be used in a given case is a question of fuel cost, operating economy, availability of electric power and the distribution of the work. The "Electric-Air" Drill will do all that an air or steam drill can do. Compared, therefore, on the basis of drilling capacity, there is no choice between the two.

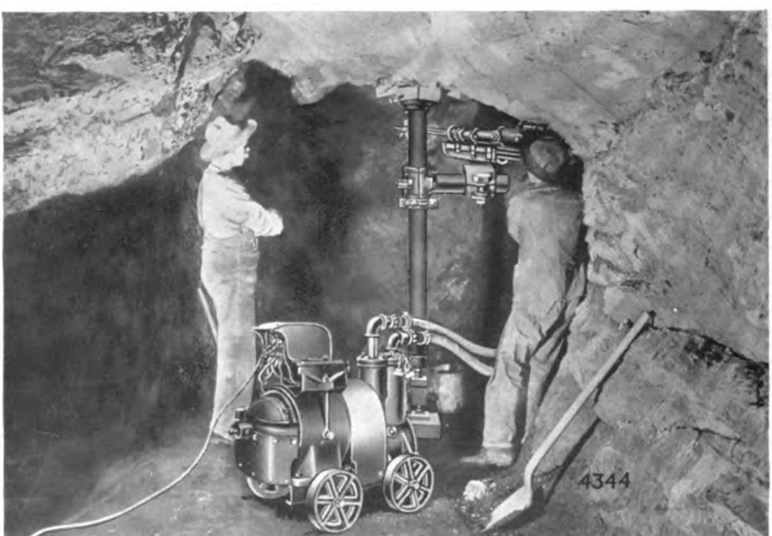
But where electric power is available and cheaper than air or steam power, due to high fuel cost; where high altitudes impair the efficiency of the ordinary air compressor; where pipe lines would be objectionable in an ordinary air drill plant; where electric distribution of power and its attendant uses and advantages are a controlling factor — these are the places where the "Electric-Air" Drill offers the best combination of maximum work output with minimum cost. Other conditions, too, may arise which, when examined in the light of the Company's experience, will recommend the new drill over the old.

The customer who entrusts his rock drilling problem to the Ingersoll-Rand Company may do so with the confidence that he will be furnished with the best and most economical driil for his particular work, whether steam, air or "Electric-Air." This is one of the advantages of dealing with a responsible firm producing a diversified line of machines adapted to all requirements.

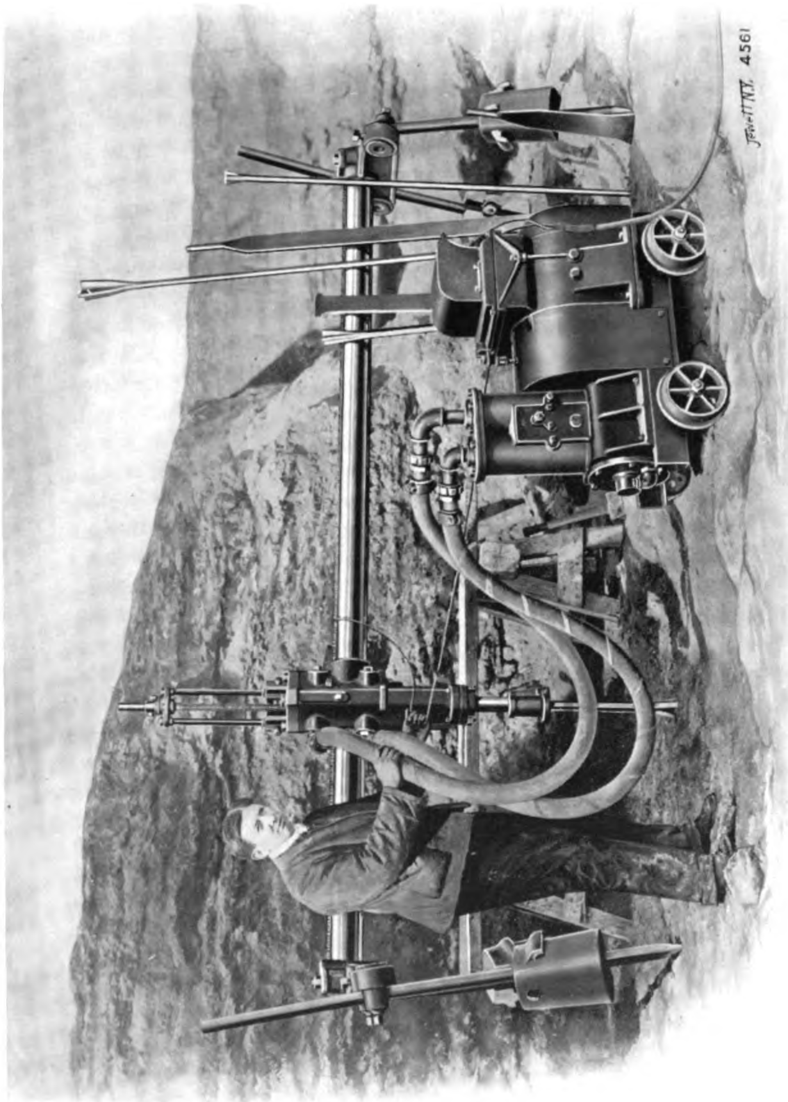
The Question of Voltages

For direct current, 220 volt equipments are considered standard by the Company; for alternating current work, 220 volt, three phase, 25, 30, 50, or 60-cycle motors are standard. The adoption of these standards is the result of observations on hundreds of "Electric-Air" Drills operating under almost all conditions. They represent what in the Company's judgment is the best for all practical purposes on the grounds of safety, economy and general satisfaction.

Motors for 440 and 500 volts D.C. will be furnished on order, though they are not carried in stock. Pressures of over 500 volts are never recommended under any circumstances, and the Company will furnish drills for these higher pressures only where the purchaser will take all the responsibility. These high pressures are called for only where the drill is to operate from an electric circuit already supplying other machines — usually an electric



ELECTRIC-AIR Drill Employed in a Western Irrigation Tunnel



A "5-C" ELECTRIC-AIR Drill Mounted on a Quarry Bar, at Work in the Quarry of the Deutscha Travertinwerke Langansalza, Thuringa, Germany

haulage system. Under such conditions, the voltage will sometimes fluctuate so widely as almost to forbid the successful operation of the "Electric-Air" Drill.

This is entirely aside from considerations of safety, for 440 volts are dangerous and 500 volts or over are occasionally fatal when encountered. Moreover, insulation and sparking difficulties increase with the voltage; and these high voltage equipments, being special, are a source of difficulty and delay in furnishing duplicate repair parts.

A voltage of 220 is a safe, practical and reliable pressure for "Electric-Air" Drill operation and is also sufficiently high for economical electric transmission. Motors for this pressure are sturdy, dependable machines and standard repair parts are always to be had at short notice. "Electric-Air" Drills seldom work under ideal conditions for electric motors; moisture and dirt must be anticipated. A voltage of 220 reduces trouble from such causes to the minimum; while above this limit difficulties will increase rapidly with the rise of electric pressure.

All new installations for running "Electric-Air" Drills should be made at 220 volts. Where a drill is to be purchased to operate from a circuit at other voltages than this, the matter should be made the subject of correspondence with the Company's engineers with a view to devising a satisfactory adjustment of pressures.

The Character of Current

The advantages and disadvantages of direct and alternating current may be stated in their relation to the "Electric-Air" Drill as follows:

Direct current was first in the field and is probably the most generally used for all purposes today. For this reason it is more familiar and the devices using it are probably better understood than is the case with the alternating current. A local mine or quarry plant is usually direct current and an electrician is regularly maintained, so that all the electrical apparatus is well cared for. The direct current motor for the "Electric-Air" Drill, when mine voltage runs too high, can be operated at three-quarters or nine-tenths its normal speed, by running with the controller on the first or second notch, continuing to do its regular work. When voltage drops below normal the compounding of the motor cares for this, though of course the drilling speed falls off.

The alternating current is usually purchased from a power company, in which case a local electrician is not often employed.

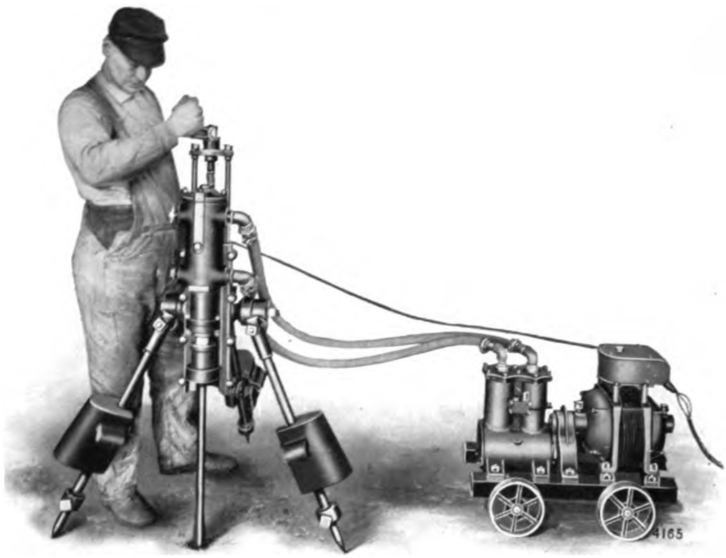
Thus the alternating current motor is less likely to get the care of an expert in its up-keep. But the A.C. motor itself is a simpler, lighter, sturdier machine than the D.C. motor and has no resistance coils, no commutator, no brushes, no uninsulated joints, etc. Power for power, the A.C. motor probably weighs one-third less than the D.C., reducing the weight of the "Electric-Air" outfit materially. The controller for A.C. motors is simpler and more compact than that for D.C. machines.

When the question of transmission to a distance is involved the problem becomes one of copper cost. For comparatively short distances direct current can be used if the wires are large enough so that the drill will not suffer under a drop in voltage. For longer distances alternating current should be used, stepped up or generated direct at high voltage for transmission and stepped down to 220 volts at the drill.

Sizes

The line of "Electric-Air" Drills covers all ordinary rock drilling requirements. The three sizes are illustrated in the following pages; and on page 22 the essential facts regarding each are tabulated. The brief descriptions on pages 16, 18 and 20 may, however, be of assistance in drawing the line of distinction between the several sizes.

ELECTRIC-AIR Drill in Austro-Hungary



A Standard "3-C" ELECTRIC-AIR Drill and Pulsator with Tripod Mounting

The "3-C" Drill

The "3-C" is the smallest in the "Electric-Air" series, the line now covering all ordinary demands of rock excavation except that class of work handled by the small hammer drill. This size corresponds with the 2-inch "Sergeant" or "Little Giant" air drill. The power used under average drilling conditions is about 3 H.P. This machine covers the same ground in drilling work as the ordinary "Baby" rock drill and is a thoroughly practical and handy device in its proper field where holes up to 6 feet in depth and of 1 1/2 to 1 3/4-inch diameter are required, as in mining, stoping, cross-cutting, drifting and quarrying.

DIRECT AND ALTERNATING CURRENT EQUIPMENT WITH "ELECTRIC-AIR" DRILLS, SIZE 3-C

Complete Outfit for 3-C "Electric-Air" Drill and Pulsator When a Direct or Alternating Current Motor is Used.

Drill

One No. 3-C "Electric-Air" Drill complete with A-50 Shell unmounted.

Conductor and Connections

50 feet of flexible protected conductor with connections.

Hose

Two lengths of special hose with couplings, plugs and caps chained together.

Direct Current Motor

One 220 volt Motor geared to Pulsator mounted on truck having flat wheels,† complete with Type 13 Controller, having three running speeds with operating cord.

Alternating Current Motor

One 220 volt Motor (either 25, 40, 50 or 60 cycles) geared to Pulsator mounted on truck having flat wheels,† complete with single speed Type 11 Controller and operating cord.

Mounting

One Double Screw Column with column arm, clamp and wrenches complete, any length specified up to 8 ft. Column may be 3, 3½ or 4-inch size, according to requirements.

OR

One single Screw Column with clamp and wrenches complete, any length specified up to 8 feet. Column may be 3, 3½ or 4-inch size, according to requirements.

OR

One A-86 Tripod with weights and wrenches complete.

Wrenches and Sundries

Suitable wrenches for drill mounting including one (1) each Nos. 63, 18, 152 and 479.

One 12-inch Coe's Monkey Wrench.
One Billings' "D" Adjustable Wrench.
One 4-inch Screwdriver.
One 1½-inch Screwdriver.
One Gear Puller and Bolts.
One Gallon Can Oil.
One M.I. Oil Can.
One Cape Chisel ⅜-inch wide.
One Front Crank Bearing Cup Leather.
Two Drill Cup Leathers.
Three Rifle Bar Plunger Springs.
One Piston Bushing.
½ lb. of Fuse Wire.
*Four Carbon Brushes.
One Test Lamp, lamp holder, wire guard and 6 feet flexible twin wire (sent only with standard 220 volt outfits).

The Following Extras are Necessarily Included as a part of each Equipment, and at an Extra Price

One Front Head.
Four Front Head Bolts and Nuts.
One Brass Nut.
One Rifle Bar.
One Back Ratchet, Nut and Nut Washer with Pin.
Six Rifle Bar Plungers.
Six Rifle Bar Plunger Springs.
Eight A-50 Shell Cap Bolts.
One Piston Chuck.
Six Chuck Pins.
Two Chuck Keys.
Four Back Head Gaskets.
Six Piston Bushings (solid).
Twelve Drill Cup Leathers.
One Pull Back Valve Body.
Two Pull Back Valve Plugs with Handles.
Two Drill Piston Rings.
One Regulating Screw and Jam Nut.
Three Back Ratchet Fibre Washers.
Two Pieces of Bare Hose.
Two 1-inch by 3-inch Nipples.
Four 1-inch by 2-inch Nipples.
Three Front Crank Bearing Cup Leathers.
One Hose Nut.
One Hose Clamp with Bolts and Nuts.
Four Hose Clamp Bolts and Nuts.
Four Hose Gaskets.
Two Terminal Sockets.

† Flanged wheels are furnished on special order.
* Furnished only with Direct Current Equipments.

A Standard "5-C" ELECTRIC-AIR Drill and Pulsator with Tripod Mounting

The "5-C" Drill

The largest drill in the "Electric-Air" series is designated by the symbol "5-C." Its proper field of application is the same as that of the larger, heavier air or steam drill, such as the drilling of large, deep holes in tunnel headings, open cut rock work in quarry or heavy contract, and large shaft sinking for any purpose. In drilling capacity it corresponds with the standard $3\frac{1}{4}$-inch "Sergeant" or "Little Giant" Drill at 80 pounds pressure. It will easily drill holes up to 16 feet in depth with a diameter of from $1\frac{3}{4}$ to $2\frac{3}{4}$ inches. It uses about 5 motor H.P., but the motor furnished has a large reserve of power available in emergency, as when drilling in very difficult ground.

DIRECT AND ALTERNATING CURRENT EQUIPMENT WITH "ELECTRIC-AIR" DRILLS, SIZE 4-E

Complete Outfit for 4-E "Electric-Air" Drill and Pulsator When a Direct or Alternating Current Motor is Used

Drill

One No. 4-E "Electric-Air" Drill complete with D-24 Shell unmounted.

Conductor and Connections

50 feet of flexible protected conductor with connections.

Hose

Two lengths of special hose with couplings, plugs and caps chained together.

Direct Current Motor

One 220 volt Motor geared to Pulsator mounted on truck having flat wheels,† and complete with Type 13 Controller having three running speeds with operating cord.

Alternating Current Motor

One 220 volt Motor (either 60, 50, 40 or 25 cycles as ordered) geared to Pulsator mounted on truck having flat wheels,† and complete with Type 19 Two-speed Controller with operating cord.

Mounting

One Double Screw Column with arm, clamp and wrenches complete any length specified up to 8 feet. Column may be 4½-inch or 5½-inch size, according to requirement.

OR

One Single Screw Column with clamp and wrenches complete, any length up to 8 feet. Column may be 4½-inch or 5½-inch size according to requirement.

OR

One E-27 Sergeant Tripod with weights and wrenches complete.

Wrenches and Sundries

Suitable Wrenches for drill mounting, including One (1) each Nos. 43, 303, 298 and 39.

One 15-inch Coe's Monkey Wrench.
One Billings' "D" Adjustable Wrench.
One 4-inch Screwdriver.
One 1½-inch Screwdriver.
One Gear Puller and Bolts.
One Gallon Can Oil.
One M.I. Oil Can.
One Test Lamp, lamp holder, wire guard and 6 feet of flexible twin wire (sent only with standard 220-volt outfits).
One Cape Chisel, ⅜ inch wide.
One Extra Front Crank Bearing Cup Leather
Two Extra Drill Cup Leathers.
Three Rifle Bar Plunger Springs.
½ lb. 15-Ampere Fuse Wire.
*Four Extra Carbon Motor Brushes.
One Piston Bushing.

The Following Extras are Necessarily Included as a Part of Each Equipment, and at an Extra Price

One Front Head.
Four Front Head Bolts and Nuts.
One Brass Nut.
One Rifle Bar.
One Back Ratchet, Nut and Nut Washer with Pin.
Six Rifle Bar Plungers.
Six Rifle Bar Plunger Springs.
Eight D-24 Shell Cap Bolts.
One Piston Chuck.
Six Chuck Pins.
Two Chuck Keys.
Three Back Ratchet Fibre Washers.
Six Piston Bushings.
Twelve Drill Cup Leathers.
Four Back Head Gaskets.
Three Front Crank Bearing Cup Leathers.
One Pull Back Valve Stud.
Two Pull Back Valve Caps and Leathers.
Two Drill Piston Rings.
One Regulating Screw and Jam Nut.
Two Pieces of Bare Hose.
One Swivel Elbow.
One Swivel Elbow Nut.
Four Swivel Elbow Gaskets.
Four Hose Clamp Bolts and Nuts.
Two Terminal Sockets.

† Flanged wheels are furnished on special order.
* Furnished only with Direct Current equipments.

Descriptive Table of Temple-Ingersoll "Electric-Air" Rock Drills

Symbol indicating size and type	**5-C**	**4-E**	**3-C**
SPECIFICATIONS:			
Diameter of cylinder ... in.	**5⅝**	**4¾**	**3⅝**
Length of stroke ... in.	**8**	**7**	**6¼**
Length of drill from end of crank to end of piston, in.	45	45	39
Depth of hole drilled without change of bit ... in.	24	24	15
Depth of vertical holes each machine will drill easily from 1 to ... ft.	16	12	6
Approximate strokes per minute ...	400	440	475
Diameter of holes drilled as desired from ... in.	**1¾ to 2¾**	**1¼ to 2**	**1½ to 1¾**
Size of octagon steel used ... in.	1⅛ and 1¼	1 and 1⅛	⅞
Size of shanks (diameter and length) ... in.	1⅛ by 6	1 by 5½	⅞ by 5
Number of pieces in set of steels, holes and depths as stated ...	8	6	5
Av. H.P. required for running drill (motor output)	5	4	3
APPROXIMATE WEIGHTS — DRILL			
Drill, unmounted, with caps, not boxed ... lbs.	**299**	**228**	**119**
Drill, unmounted, with caps, boxed ... lbs.	355	281	155
Hose, fittings and wrenches, not boxed ... lbs.	65	75	35
Hose, fittings and wrenches, boxed ... lbs.	115	150	65
Tripod, without weights, not boxed ... lbs.	296	224	145
Tripod, without weights, boxed ... lbs.	320	260	170
Tripod weights, not boxed ... lbs.	370	336	255
Tripod weights, boxed ... lbs.	400	370	280
Entire equipment, including drill, pulsator, alternating current motor, fittings, wrenches and extra parts, but no mountings, steels or blacksmith tools, boxed ... lbs.	**1755**	**1690**	**925**
Entire equipment, including drill, pulsator, direct current motor, fittings, wrenches and extra parts, but no mountings, steels or blacksmith tools, boxed ... lbs.	**1985**	**1740**	**1155**
APPROXIMATE WEIGHTS WITH PULSATOR ARRANGED FOR DIRECT CURRENT MOTOR			
Pulsator complete, mounted on truck with motor, controller and length of cable, not boxed ... lbs.	**1050**	**950**	**525**
Pulsator complete, mounted on truck with motor, controller and length of cable, boxed ... lbs.	1400	1400	850
Pulsator alone, less truck, not boxed ... lbs.	320	320	88
Pulsator alone, less truck, boxed ... lbs.	370	370	125
Motor alone, not boxed ... lbs.	495	390	274
Motor alone, boxed ... lbs.	600	495	330
Armature alone, not boxed ... lbs.	100	100	60
Armature alone, boxed ... lbs.	125	125	95
D.C. controller type 16 for 5-C and 4-E, type 13 3-C, not boxed ... lbs.	75	75	53
D.C. controller type 16 for 5-C and 4-E, type 13 3-C, boxed ... lbs.	100	100	80
APPROXIMATE WEIGHTS WITH PULSATOR ARRANGED FOR ALTERNATING CURRENT MOTOR			
Pulsator complete, mounted on truck with motor, controller and length of cable, not boxed ... lbs.	**1050**	**950**	**370**
Pulsator complete, mounted on truck with motor, controller and length of cable, boxed ... lbs.	1300	1300	625
Pulsator alone, not boxed ... lbs.	320	320	88
Pulsator alone, boxed ... lbs.	370	370	125
Motor alone, not boxed ... lbs.	375	375	136
Motor alone, boxed ... lbs.	490	490	170
Rotor alone, not boxed ... lbs.	90	90	34
Rotor alone, boxed ... lbs.	120	120	50
A.C. controller type 12 for 5-C, 4-E, type 11 for 3-C, not boxed ... lbs.	34	34	15
A.C. controller type 12 for 5-C, 4-E, type 11 for 3-C, boxed ... lbs.	50	50	35
SHIPPING MEASUREMENTS (OVER ALL)			
Box for unmounted drill ... ft. in.	4^{0} 1^{4} 1^{4}	3^{10} 1^{2} 1^{2}	3^{6} 1^{1} 1^{0}
Box for pulsator, motor and switch mounted on truck and cable ... ft. in.	4^{0} 4^{0} 3^{2}	4^{4} 2^{3} 3^{10}	3^{0} 3^{0} 2^{4}
Box for hose, fittings and wrenches ... ft. in.	2^{10} 2^{8} 0^{8}	3^{1} 2^{10} 0^{10}	2^{4} 2^{2} 0^{6}
Box for pulsator ... ft. in.	2^{6} 1^{6} 2^{2}	2^{3} 1^{9} 2^{6}	2^{0} 1^{2} 1^{7}
Box for motor ... ft. in.	2^{6} 1^{10} 1^{10}	2^{6} 1^{10} 1^{10}	2^{0} 1^{0} 1^{0}
Box for truck ... ft. in.	3^{6} 1^{0} 0^{9}	4^{2} 1^{0} 0^{9}	2^{7} 2^{0} 0^{10}
Box for armature ... ft. in.	3^{0} 1^{0} 1^{0}	2^{6} 0^{10} 0^{10}	2^{3} 0^{10} 0^{10}
Box for "D.C." switch and rheostat ... ft. in.	1^{6} 1^{6} 1^{0}	1^{10} 1^{3} 1^{3}	1^{0} 1^{0} 0^{8}
Box for "A.C." controller switch ... ft. in.	1^{5} 1^{0} 1^{0}	1^{4} 1^{1} 1^{2}	1^{2} 1^{0} 1^{0}
Box for tripod ... ft. in.	3^{9} 1^{6} 0^{10}	4^{5} 1^{6} 0^{10}	3^{0} 1^{3} 0^{9}
Box for tripod weights ... ft. in.	2^{7} 1^{1} 0^{10}	2^{7} 1^{0} 0^{10}	2^{0} 0^{10} 0^{9}

NOTE.—For size and weights of single and double screw columns see separate pamphlet, Form No. 9003.

Engine and Generator Sizes for Operating Temple-Ingersoll "Electric-Air" Drills

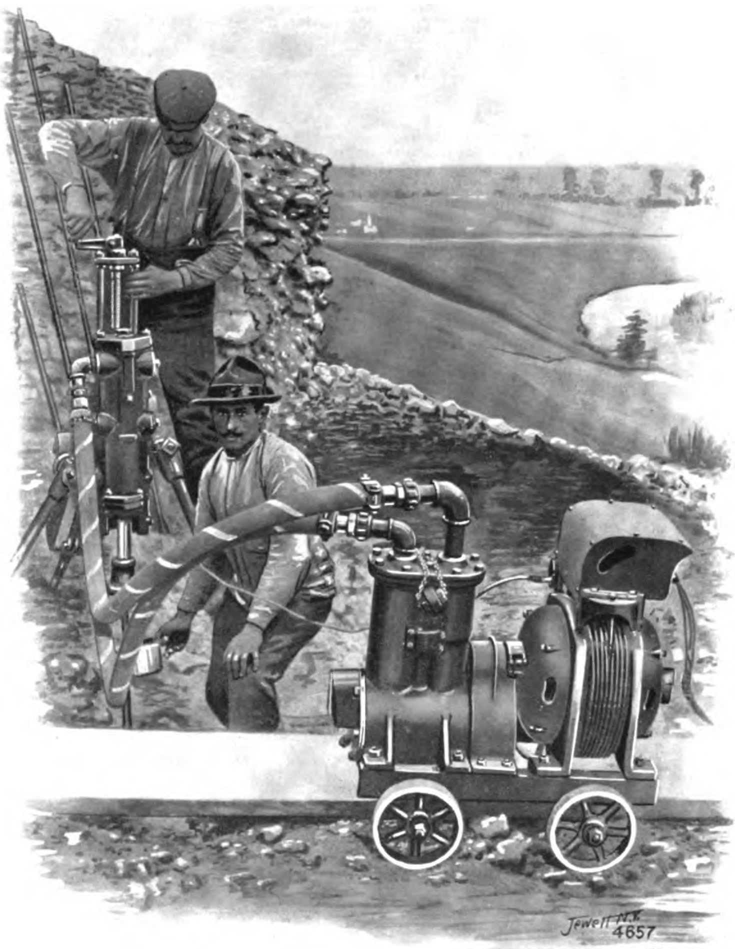
Number of Drills	Electrical Power at Drills K.W. (Input)			Equivalent Horse-Power at the Terminals of the Drill Motors (Input)			Generator Capacity Required K.W.			Equivalent Engine Power Required — Brake H.P.		
	5-C	4-E	3-C	5-C	4-E	3-C	5-C	4-E	3-C	5-C	4-E	3-C
FOR DIRECT CURRENT OPERATION (For Alternating Current Operation see Notes below)												
1	4.4	3.5	2.2	5.8	4.6	2.9	6.0	4.8	3.0	8.0*	6 4	4*
2	8.1	6.5	4	10.5	8.4	5.2	11	8.8	5.3	14	11.2	7.2
3	11.7	9.4	6	15	12	7.5	16	12.8	7.6	21	16.8	10
4	15	12	8	20	16	10	20	16	10	27	22	14
5	19	15	9	24	19	12	25	20	12	33	26	16
6	22	18	10	28	22	13	29	23	14	39	31	18
7	25	20	12	33	26	16	33	26	16	45	36	21
8	28	22	13	38	30	17	38	30	18	51	41	24
9	31	25	14	41	33	19	42	34	19	56	45	26
10	34	28	15	45	36	20	46	37	20	62	49	27
11	37	30	16	49	39	21	50	40	22	68	54	29
12	40	32	17	52	41	22	54	43	23	72	58	31

*It is necessary to provide more engine and generator capacity for one drill than the average load demands, on account of the requirements of starting and stopping.

NOTES. — The above figures are for average conditions of operation. They do not provide for the simultaneous continuous running of all drills, but only for average intermittent use, as found in ordinary drilling conditions.

The generator capacities given above allow for the following losses: For direct current work, for a line loss of 8 to 10 per cent; for alternating current work, for a line loss of 8 to 10 per cent and a line power factor of 70 per cent. In other words, an alternating current generator must have a kilo-volt-ampere capacity 30 per cent larger than that listed above under "Generator Capacity."

Where an alternating current generator is used, the above figures must be increased to allow for the exciter.



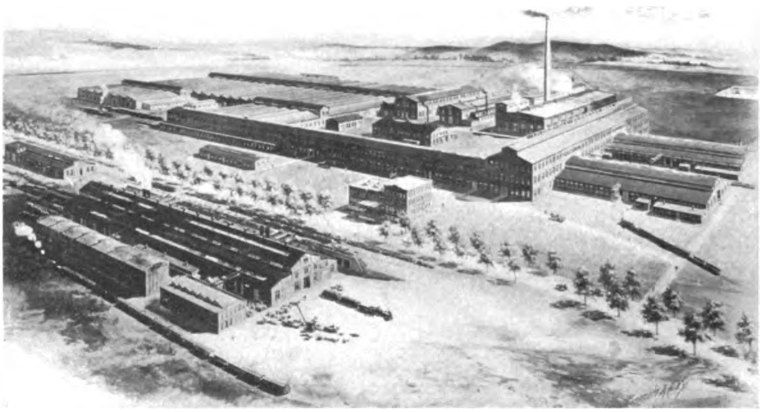
An ELECTRIC-AIR Drill in the Quarry of the
Stranska Skala Company, Bohemia

Griffith - Stillings Press
368 Congress St. Boston

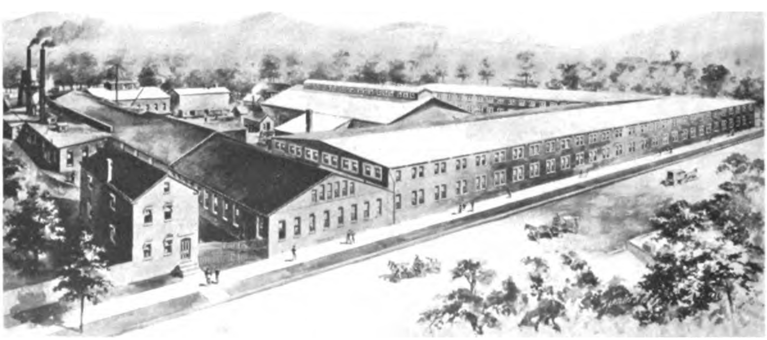
Rock Drill Guarantees

THE Standing Guarantee of the Ingersoll-Rand Company is to make good at its works, by repair or replacement, any defect in the workmanship or material of its drills which may develop within one year from date of shipment. ¶ The Ingersoll-Rand Company furthermore furnishes its rock drills under a standing absolute guarantee of interchangeability of parts. ¶ The Ingersoll-Rand Company further guarantees that such is the care exercised in the selection of materials, in the workmanship applied, and in the methods of production, that its drills, under fair treatment and reasonable freedom from abuse, will give better results, with the minimum of delay and expense for repairs, for a longer period than those of any other builder.

The Shops Where Ingersoll-Rand Rock Drills Are Made



Plant of Ingersoll-Rand Co., at Phillipsburg, N. J.



Plant of Ingersoll-Rand Co., at Painted Post, N. Y.

Rock Drill Construction

In a machine for drilling rock, certain fundamental requirements are involved. First of all, its design and construction must be based upon a perfect understanding of all drilling difficulties and conditions—an understanding to be gained only by the longest experience. Cutting speed demands a heavy and effective blow, a powerful return, a rapid stroke, and a structure strong enough to resist the repeated shocks. The force of the blow must be under full and ready control, that the best work may be obtained under varying conditions. The method of this control must be simple, that the machine may be handled effectively by labor of average skill.

No machine is subjected to more severe service than the rock drill; its very ruggedness seems to invite abuse. Great strength, endurance and power, therefore, are required, yet weight must be kept within the limits of portability—conflicting requirements which can be met only by the judicious selection of the best materials for every part. Furthermore, the vital working parts must be as few in number as possible, and well protected against injury, so that effective operation may be steadily maintained in service. The design must be so simple that the average mechanic can keep the machine in condition of greatest usefulness. Finally, interchangeable construction must assure readiness of repair with least possible delay.

A recognition of these requirements as outlined has brought Ingersoll-Rand Rock Drills to their present high state of development. In them are embodied the results of more than a generation devoted to the manufacture of percussive machine drills. They are distinguished by high power, great strength, marked economy, extreme simplicity and an unmatched reliability. They represent in highest degree the attainment of the drill builder's ideal—the embodiment of ECONOMY, SIMPLICITY and RELIABILITY in rock-drilling machinery.

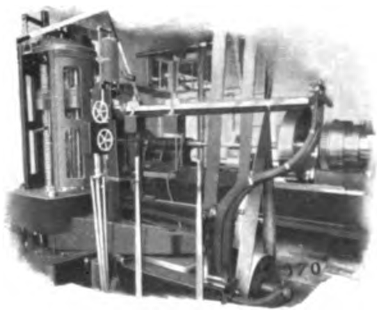
Various Types

Conditions of service vary so that it is impossible to build a single pattern which will be equally effective in rock of every quality. An understanding of this fact has produced the standard

types of Ingersoll-Rand Drills illustrated in pages following and described in separate pamphlets. Among these standards will be found some one machine adapted to each peculiar drilling condition. Either air, steam or electricity may be the motive power. Distinctive details of construction and design mark each type, and are emphasized in the individual pamphlets listed; but there are certain features in a sense common to all, which, to avoid repetition, will be discussed at this point.

Materials

Whatever the *kind* of material, there is only one ***quality*** used in Ingersoll-Rand Drills—*the very best.* The strains and shocks to which each part is subjected have been given closest study. Only that grade of material is adopted which experience and test have shown to be best suited to each local demand. Special grades of metals are used, selected because of some valuable quality. The best of high-carbon steel is employed, the percentage of carbon varying with special needs. High carbonization gives a harder, tougher, stronger and more durable steel. Double-refined and malleable iron are applied where best suited.



The Materials Testing Room

Treatment

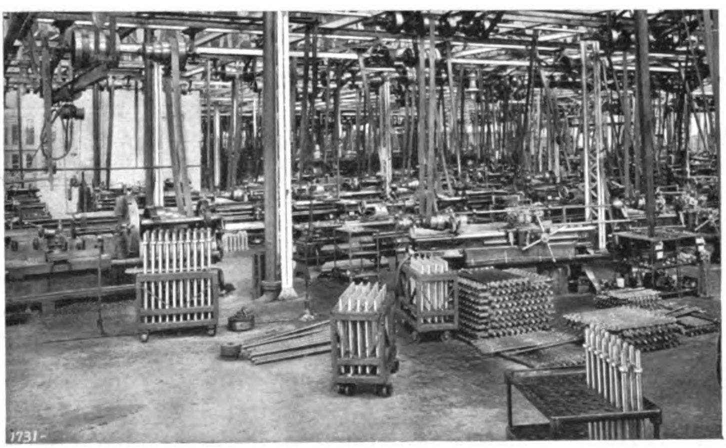
Steel parts are given an oil treatment as thorough as that adopted by the United States Government for ordnance forgings. The steel, after rough turning, is heated to a high temperature, plunged in oil and allowed to cool there. It is then annealed. The result is a tensile strength

Oil Treating Department

increased 25 to 30 per cent. over that of steel not so treated; and the pieces are relieved by annealing from all internal strains produced in forging, straightening, or cooling. No other maker has considered himself justified in going to this heavy expense, but no cost is spared which will measurably contribute toward making "Ingersoll-Rand" synonymous with "best." A valuable detail of the machining process is the fact that, wherever possible, grinding instead of turning is employed on the finishing cut. This gives a smoother, truer surface, assures absolute accuracy and insures closer fits.

Workmanship

Only the highest class of skilled workmen are employed on Ingersoll-Rand products; and personal inspection is carried to such a degree that the greatest care and precision in every detail of workmanship is enforced. Furthermore, shop organization is such that it is to the interest of every employe to strive after an improvement in his product and a betterment in the character



A View of One of the Drill Departments

of his work. The welfare of Company, workman and product are inseparably associated.

Automatic machine tools eliminate, so far as possible, the personal factor in the manufacturing process and assure a dimensional uniformity of product. Parts are put through in lots of hundreds and thousands. Yet each part is separately inspected

and referred to a system of "limit gages" guaranteeing duplication to thousandths of an inch.

Interchangeability

This test by limit gages is an interesting example of the degree of refinement to which Ingersoll-Rand methods have been carried. For such parts as pistons and spool valves, two ring gages are provided; these are hardened and ground, the diameter of the opening in one being one one-thousandth of an inch larger than that in the other. One must pass over the part under inspection and the other must not. This means that if the part is too small by one two-thousandth of an inch, both gages will pass over; if too large by an equal amount, neither will pass over. In either case the part is rejected. For bored parts, such as cylinders and valve chests, two plug gages are used in a similar manner. Thus correctness of size averaging within one one-thousandth of an inch is maintained in every part. *No other manufacturer does this.* The method is one which guarantees absolute uniformity of dimensions. This perfect interchangeability is of vital importance in rock drills—used, as they are, in quarries, mines and tunnels so often remote from machine shop facilities. When repair parts for Ingersoll-Rand drills are ordered it will be with the assurance that they will fit in place absolutely; and the machine, in that element, will be as good as new.

Tests

Every drill is fully assembled at the shops and given a thorough test run under conditions as severe as those of actual service. Its performance is noted, any imperfections which may appear are corrected, and all adjustments are made. It is then taken apart, every piece examined and, if right in every detail, reassembled. Each drill leaves the shop in perfect condition and in proper adjustment, ready for any service. These shop adjustments should not be changed, except by an expert drill man.

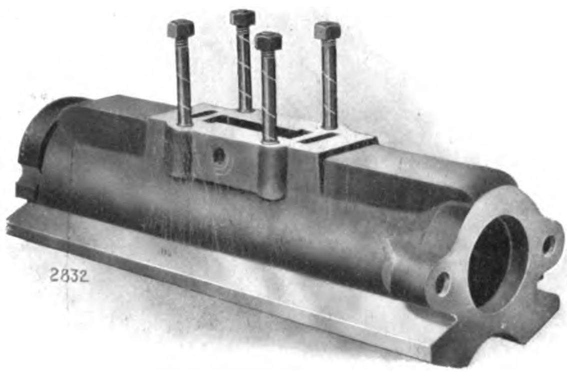
Performance

The field of usefulness of the Ingersoll-Rand Rock Drill is everywhere and anywhere that a hole in rock is desired, of any diameter, to any depth and at any angle. In the mine it is used in shaft sinking, drifting, tunneling and stoping. In the quarry it finds its place for drilling wedge holes, "plug-and-feather" work, broaching, blasting and the breaking of detached

blocks. In contract work, no rock excavation is attempted without its assistance.

The heavy blow of the Ingersoll-Rand Rock Drill gives great cutting speed. Its ready adjustments and the several types adapt it to any rock and any service. Its powerful back stroke is very effective in soft or broken material which has a tendency to bind the steel; and in "mudding" qualities these drills are unsurpassed.

The most common mounting in all classes of service (except perhaps in mining) is the tripod. In mining and tunneling, the column and shaft bar are most frequently used. In the quarry, the tripod and the quarry bar find their greatest usefulness. These several mountings are described in Pamphlet 9003.



A Finished Rand Drill Cylinder with V-Guides

Cylinders and Valve Chests

These parts are cast of a tough, close-grained charcoal iron, absolutely uniform in quality and with a high resisting power. It wears under proper lubrication to a high polish. The castings are reinforced at proper points, and weight reduced as much as possible consistent with strength. Ground and surfaced joints dispense with all gaskets, prevent troublesome leaks, and ensure perfect alignment.

Shell, Feed Screw, Standards, Etc.

This important part, with its guide caps or slides, is made of a tough malleable iron or cast steel. The guide surfaces are unusually wide, with caps separate and adjustable for wear, except in small sizes where this refinement would involve unnecessary complication.

Feed screws are made of tough, open-hearth steel and turn in feed nuts of hard steel. The standards are forged from high-grade steel. The feed cranks are tough malleable castings; and the cross-heads are of a selected metal.

An Ingersoll Shell with Square Guides, complete with Feed Screw, Crosshead and Standards.

The "15" Type Front Head

INGERSOLL-SERGEANT DRILLS

The "15" Type Front Head, Steam and Air Patterns

This front head is made in two types: one, for steam, has a gland and proper stuffing box; the other, for air, has a cup leather. The steam head may be used for air, but steam must never be used with the air head. Both patterns are long and reamed to perfect trueness, giving an ample piston guide. Powerful through-bolts hold them in place and transfer all strains directly to the cushion springs in the rear. The joints between head and cylinder are ground—no gasket or packing is used.

The "58" Type Front Head

INGERSOLL-SERGEANT DRILLS

This is another standard device designed for use with air. Its construction is shown in the illustration. The head proper is of cast steel, split; and within it is the piston bushing of cast

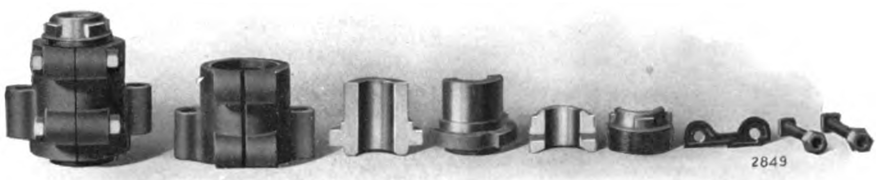
A "58" Type Front Head, for Air Only

iron, renewable when worn. Over this head slips a taper ring of cast steel, which receives the through-bolts, a cup leather held between the head and a flange on the bushing providing the necessary packing. It is a front head of great simplicity and strength, of great endurance in severe service; it is next to impossible to break it.

Two-Bolt Split Lower Head

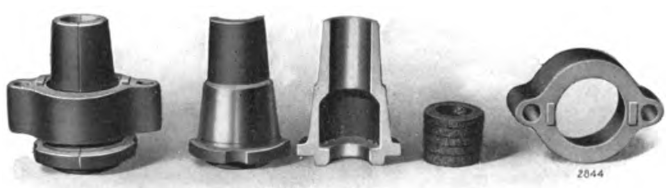
RAND DRILLS

This is a standard type, adapted to either steam or air. The head proper is a malleable casting, split on one side, with two bolts for taking up wear, these being clamped down tight, in practice, on a copper strip of suitable thickness. In the rear of this head fits the split bushing, in front of which is the split stuffer.



Two-Bolt Split Lower Head — Parts Assembled and Separate

A third ring is screwed into the stuffing box when air is used, holding the air packing in place. The bushing and stuffer are of steel.



Ring Lower Head — Parts Assembled and Separate

*The Ring Lower Head

RAND DRILLS

This is another standard type adapted particularly to the use of steam. The head is a split drop forging of steel, machined on a taper to receive the ring. It is accurately bored and reamed to fit the chuck rod, and is recessed to receive the steam packing.

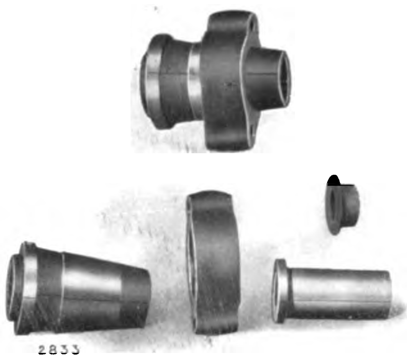
***This head is not furnished with the "Slugger" drill, which is essentially an air driven machine.**

The ring is a steel drop forging bored on a taper to fit the head, over which it is drawn tight by the tension of the side rods.

The C. & H. Ring Lower Head

RAND DRILLS

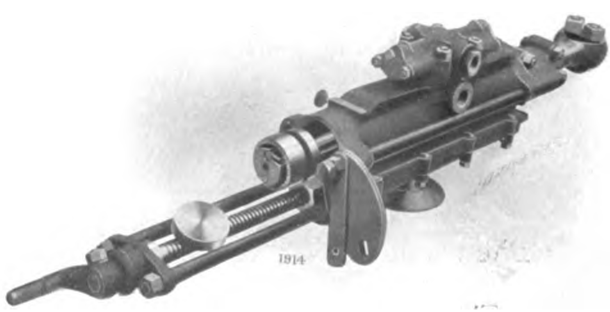
This is a modification of the previous type, designed for use with air. In this style the split malleable head is bored to receive a split bushing of cast iron, accurately fitting the chuck rod. A cup leather held in the rear between bushing and head furnishes the packing necessary. All strain on the head proper is taken up by the taper fit of the steel ring over the head under the tension of the side rods and buffer. The bushings may be removed and replaced when worn.



C. & H. Ring Lower Head—Parts Assembled and Separate

Cushion Spring

The "Sergeant" Flat Cushion Spring is used on the latest models of Rand Drills and on all but the "Eclipse" type of Ingersoll-Sergeant drills. It is one of the most valuable improvements made in the history of rock drills. It rarely breaks and can be made anywhere. Oil cannot affect it, nor does it deteriorate with exposure or use. In these respects it is far superior to rubber cushions or coil springs. It protects both heads and is the safest and most durable head-cushion device yet produced. The back head and parts of the rotating device



Cushion Spring, Strap, Washer and Rotation Removed

are retained by the spring and fit in place on ground joints. Loosening the two through-bolts practically takes the whole drill apart.

Sergeant Slip Rotation

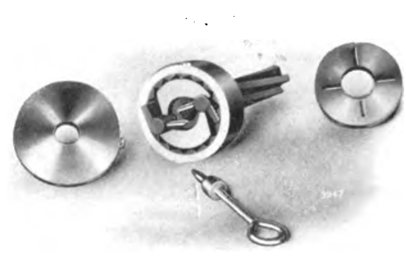
Sergeant Rotation

The Sergeant "Slip Rotation" is one of the most valuable features of the more recent models of Ingersoll-Rand drills, permitting the machine to free itself in a binding, caving material without injury to steels or piston. The rachet is held by friction between the rotation washer and the back head, under pressure of the cushion spring. It is thus free to slip when the steel "glances" or twists backward, freeing the bar from twisting strains; and by changing the spring tension, the friction effect may be varied to meet different service requirements. The ratchet and pawls are case-hardened, and the device is one of great durability and strength.

Pawl Release Rotation

The Sergeant "Pawl Release Rotation", furnished on certain Ingersoll-Sergeant types, is a device by the use of which the piston may either be freed from rotation or, if desired, made to rotate in the usual manner.

When broaching between a series of parallel holes, the pawls are held out of engagement with the teeth of the rotation ratchet by means of a "pawl release plug." This allows the rifle bar to turn on both the forward and backward stroke of the piston, thus doing away with the automatic rotation of the latter.



Details of Sergeant Pawl Release Rotation

A "pawl release plug handle" is furnished for

inserting and withdrawing the pawl release plug. The "pawl release back head screw" holds the pawl release plug in place while the latter is in use and at all other times is screwed into the back head to close the hole.

When the "pawl release plug" is not used the rotation is exactly the same as if the drill were fitted with the standard Sergeant "Slip Rotation," described in the foregoing article. Drills fitted with the "Release Rotation" require a special back head, cushion springs, cushion spring strap, pawls and rifle bar.

Rand Rotation

Most of the standard models of Rand drills can be equipped with this device, which has given satisfactory service for almost a quarter of a century and is preferred by many large users. The ratchet teeth are cut on a separate ratchet keyed to the rotating bar. Ratchet and bar are hardened. Two pawls of hardened steel, turning on hardened pawl studs, engage the ratchet, flat pawl springs giving the necessary tension. The entire rotation is enclosed between the ratchet box and upper head, these parts as a unit being held in place by the side rods and buffer.

Pistons

Long and heavy pistons give a powerful blow, while reducing the tendency to cut in the cylinders. A special open hearth nickel steel of highest quality is used. Piston, rod and chuck are forged solid, then oil-toughened and annealed. By a special process the wearing portions are hard-

A Rand Drill Piston and Chuck

ened. The whole is then mounted on centers and ground to a plug fit, the result being a *hardened* piston with a *tough* rod and chuck. Wear thus comes upon the cylinder and front head—parts more cheaply replaced than the piston. The chuck key is of hardened steel, the U-bolt oil-tempered and annealed.

Rock Drills

The "Sergeant" Drill

An "all-around" drill for hard, medium, or soft rock with a positive, independent valve action, a variable stroke, an uncushioned blow, and an enormous drilling capacity. Pamphlet 4102.

The Rand "Little Giant" Drill

A powerful drill of tappet type, embodying the highest refinements of design, especially adapted to the use of steam, but giving the best results with compressed air. Pamphlet 4003.

The "Arc Valve" Tappet Drill

A modern, improved tappet drill for uniform rock of medium hardness, especially adapted for the use of steam, but more effective with air. Pamphlet 4004

The Rand "Slugger" Drill

An improved drill of independent, air-thrown valve type, designed for heavy work and rapid drilling; adapted only for the use of compressed air. Pamphlet 4005.

The "New Ingersoll" Drill

A good, all-round drill, using steam or air, with an independent valve movement and certain special features of great utility. Pamphlet 4006.

The "Eclipse" Drill

The earliest successful rock drill, with an independent valve, still standard with many large users because of its simplicity and great capacity. Pamphlet 4007.

The "Electric-Air" Drill

The only successful application of electric power to rock drilling, with electrical economy and flexibility combined with the capacity and rugged endurance of the standard rock drill. Pamphlet 4009.

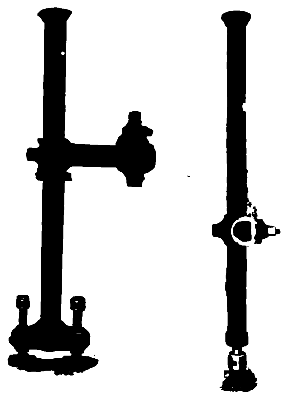
"Crown" and "Imperial" Hammer Drills

Small machines for the lightest work in mine, quarry or contract, adapted for all purposes where hand drilling is usually employed and giving a great saving in cost on this class of work. Pamphlets 4010 and 4011.

Drill Mountings

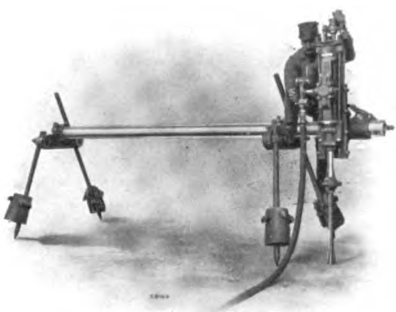
The Tripod

A standard mounting of great adjustability and strength, especially adapted for open excavation in quarry and contract work. Pamphlet 9003.



The Column

A strong, rigid, adjustable mounting, universally used in tunnelling, and in mining for shaft sinking, drifting, and stoping. Pamphlet 9003.



The Quarry Bar

A standard mounting in quarry work, widely adjustable, for drilling "plug-and-feather" holes, "lofting," broaching and cutting key blocks. Pamphlet 9003.

The Gadder

A distinctive portable device for quarry work, using standard drills, for drilling parallel holes in a plane at any angle. Pamphlet 9003.

Suggestions for Intending Purchasers

Particular attention is called to the code words used in rock drill pamphlets. The construction of these words is such that the liability of error on account of telegraphic signals is reduced to a minimum. They are made up of roots and terminals, both of which have a meaning. In some cases the meaning of the root is merely to signify the page from which the terminal is taken; in other cases the roots have a complete and distinct meaning when prefixed to a terminal.

It must be distinctly understood that a root or terminal alone does not constitute a word. Two roots or two terminals joined together are not permissible, but it is absolutely necessary that one root and one terminal be joined to make a word.

The use of these words is urged at all times in telegraphing, when it is convenient to do so, for the reason that these words are checked for signals and are less liable to mistakes than ordinary English words.

As code words sometimes become mutilated in transmission, it is always well to have the telegraph company repeat these particular words, which they will do free of charge, and it makes one surer that they are correct.

When using telegraph or code words *never add "s" or "es" to make them plural.* If more than one article is wanted, put the number desired before the word for that article, *but do not change* the code word. Too much care cannot be observed in making out orders, and every possible identification mark should be given to verify the items.

Information Required for Estimates

In asking for quotations on a rock drilling plant for specific purposes, the Company will be best able to advise if given the fullest information possible as to working conditions; and intending purchasers are requested to answer in full any and all of the following questions:

In Quarrying

1. Give the location of work, whether on surface or underground.
2. Describe the nature of the rock, whether sandstone, slate, limestone, granite, marble, etc. State whether the material is hard, medium or soft.
3. Is the quarry output in dimension stone or simply broken rock?
4. If the material is shelly, state whether it is tight or loose.
5. What is to be the extreme depth of holes? Are there many or few of these deep holes?
6. What is the average depth of the holes to be drilled? (This is important.)
7. What is to be the average diameter of the holes at the bottom? If undecided, state whether dynamite or black powder is to be used.
8. What is the greatest distance to which steam will have to be piped or will ever be used?
9. A rough sketch of the quarry is very useful, and also a small sample of the material to be quarried. If the latter is sent, it should be properly labeled with the name and address of the sender and prepaid; a 3-inch or 5-inch cube is a good size.

In Railway Cut or Excavation

10. Give the full dimensions of the cut, and in addition answer such questions in above list as may apply to the case.

In Sewer or Trenching Work

11. Give answers to questions Nos. 2, 4, 6, 7, 8 and 9 above.
12. Give the width and depth of the trench, stating the depth of the rock which is to be removed, and depth of earth (if any) over the rock.

In Metal Mining

13. Give full information as to the nature and quality of the ore.
14. Describe the general system of mining.
15. Give the dimensions of the shafts, drifts, stopes and winzes which are to be driven.
16. If a compressed air equipment is desired, answer the questions under the heading of "Compressed Air," on the following page.

In Tunneling

17. What is the nature of the material which is to be passed through?
18. Dimensions of tunnel?
19. What is to be the total length?
20. Are heading and bench to be driven together, or will a heading be driven first and the bench removed afterward?
21. Is the tunnel to be driven from one end only, or from both?
22. Are intermediate shafts to be sunk? If so, give their depth and cross-section, and describe the material to be penetrated.
23. If compressed air is to be used, distributed by pipes leading from a central station, these stations should be located where coal and water are most readily accessible. In such cases answer the questions under the heading "Compressed Air" below.

In Shaft Work

24. What are to be the dimensions of the shaft?

25. Give the depth proposed and nature of the rock or ore penetrated. If compressed air is to be used, answer the questions under that head below.

In Submarine Drill Work

26. Give the greatest depth of water over the rock to be excavated.

27. Give the depth of rock which is to be blasted and the depth of the holes to be drilled. If possible, state a maximum and minimum depth required.

28. Give the rise and fall of the tide, if any.

29. Give the velocity of the current, if any.

30. State whether the drilling is to be done from a scow, pontoon, platform or whatever support is used.

31. State whether the rock is covered with mud, clay, gravel or sand, and if so, to what depth.

Where Compressed Air is to be Used

32. State the altitude above sea level at which the compressor is to be located.

33. Give a general idea of the location and arrangement of the plant.

34. State how near the plant is to fuel and water, and the kind and cost of the fuel.

35. State how far the compressing plant is from the work to be done.

36. If other machinery than drills is to be run by air, give the cylinder dimensions, the speed, the pressure necessary, the running time, the location, and other information likely to be of service.

37. State whether the compressor is to be run by steam, electricity or water power.

38. Give the steam pressure which is to be used.

39. State whether the compressor is to run condensing or non-condensing. If condensing, state quality, temperature and quantity of water available.

40. If a boiler is already available, state its rated horse-power.

41. State how long the work is to last, and whether the most economical or a cheaper plant is contemplated.

42. If water power is to be used, state head and quantity available.

43. If compressor must be sectionalized, state limit of weight permissible.

Where Electric Power is to be Used

44. Have you or will you install your own electric power plant, or will current be taken from some Power Company's line?

45. What is the source of power—steam, water power, gasoline, producer gas, distillate, oil engine, etc.?

46. What is the degree of speed and voltage regulation?

47. Is alternating or direct current used?

48. If alternating current, what is the phase, and the frequency or cycles per second?

49. If alternating current, what is the primary voltage of line and transformers?

50. If any variation in voltage, what are the maximum and minimum?

51. Are electric locomotives or hoists operated from the same circuit?

52. What is the average voltage of current at drill?

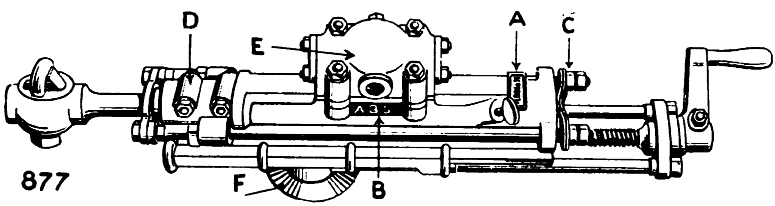
53. What is the maximum distance to be wired from generator or transformer to drill?

54. What electric equipment is now in use?

55. What amount of current in addition to drill requirements must be allowed in case a complete new installation is to be installed?

Repair or Duplicate Parts

DUPLICATE or repair parts should be ordered wherever possible from the Duplicate Part Sheet belonging to the particular drill or other machine in use; and the name and number of the part, as well as the name, shop or serial number, and symbol of the complete machine should be specified in the order.



A. Shop or Serial Number, Ingersoll and Rand Types.
B. Drill Symbol, Ingersoll Types.
C. Style of Upper or Back Head, Rand Types.
D. Style of Lower or Front Head, Ingersoll and Rand Types.
E. Style of Chest (Air or Steam), Rand Types.
F. Style of Shell (Ingersoll, Sergeant or Rand), Ingersoll and Rand Types.

Diagram indicating information necessary to fill orders for duplicate parts.

The drill serial number is always stamped on the boss or numbering space. In late models this is on the top of the cylinder near the back head. While the most careful records are kept of every piece of machinery ever built by the Company, still drill numbers are at present running above 90,000 and without this serial number the Company cannot guarantee the right part to fit any particular drill. If correct information is not furnished with the order, delay inevitably results while awaiting further data by mail. The figure above shows the necessary markings on each drill; all information suggested by this drawing and its notes should be made a part of each order for repairs. Full shipping directions, including the county, should accompany each order.

DRILL CAPACITY TABLES

THE following tables are to be used to determine the amount of free air required to operate rock drills at various altitudes with air at given pressures.

The tables have been compiled from a review of a wide experience and from tests run on drills of various sizes. They are intended for average work in ordinary hard rock, but owing to varying requirements it is impossible to make any guarantee without a full knowledge of existing conditions.

In soft material, where the actual time of drilling is short, more drills can be run with a given sized compressor than when working in hard material, where the drills would be working continuously for a longer period, thereby increasing the chance of all the drills operating at the same time.

In tunnel work, where the rock is hard, it has been the experience that more rapid progress has been made when the drills were operated under a high air pressure, and that it has been found profitable to provide compressor capacity in excess of the requirements by about 25 per cent.

No allowance has been made in the tables for loss due to leaky pipes, or for transmission loss due to friction; but the capacities given are merely the displacement required, so that when selecting a compressor for the work required, these matters must be taken into account.

Table I gives cubic feet of free air required to operate one drill of a given size and under a given pressure.

Table II gives multiplication factors for altitudes and number of drills by which the air consumption of one drill must be multiplied in order to give the total amount of air.

Table I.

Cubic Feet of Free Air Required to Run One Drill of the Size and at the Pressure Stated Below

Gage Pressure	CYLINDER DIAMETER OF DRILL												
	2″	2¼″	2½″	2¾″	3″	3⅛″	3 3/16″	3¼″	3½″	3⅝″	4¼″	5″	5½″
60	50	60	68	82	90	95	97	100	108	113	130	150	164
70	56	68	77	93	102	108	110	113	124	129	147	170	181
80	63	76	86	104	114	120	123	127	131	143	164	190	207
90	70	84	95	115	126	133	136	141	152	159	182	210	230
100	77	92	104	126	138	146	149	154	166	174	199	240	252

Table II.

Multipliers to Determine Compressor Capacity Required to Operate from 1 to 70 Rock Drills at Altitudes above Sea Level

Altitude Above Sea Level	NUMBER OF DRILLS																		
	1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	40	50	60	70
	MULTIPLIERS																		
0	1.	1.8	2.7	3.4	4.1	4.8	5.4	6.0	6.5	7.1	8.1	9.5	11.7	13.7	15.8	21.4	25.5	29.4	33.2
1000	1.03	1.85	2.78	3.5	4.22	4.94	5.56	6.18	6.69	7.8	8.34	9.78	12.05	14.1	16.3	22.0	26.26	30.3	34.2
2000	1.07	1.92	2.89	3.64	4.89	5.14	5.78	6.42	6.95	7.60	8.67	10.17	12.52	14.66	16.9	22.9	27.28	31.46	35.52
3000	1.10	1.98	2.97	3.74	4.51	5.28	5.94	6.6	7.15	7.81	8.91	10.45	12.87	15.07	17.38	23.54	28.05	32.34	36.52
4000	1.14	2.05	3.08	3.88	4.67	5.47	6.15	6.84	7.41	8.08	9.23	10.83	13.34	15.62	18.01	24.4	29.07	33.52	37.8
5000	1.17	2.10	3.16	3.98	4.8	5.62	6.32	7.02	7.61	8.31	9.48	11.12	13.69	16.03	18.49	25.04	29.84	34.4	38.84
6000	1.20	2.16	3.24	4.08	4.9	5.76	6.48	7.2	7.8	8.52	9.72	11.4	14.04	16.44	18.96	25.68	30.6	35.4	39.84
7000	1.23	2.21	3.32	4.18	5.04	5.9	6.64	7.38	7.99	8.73	9.96	11.68	14.39	16.85	19.43	26.32	31.36	36.16	40.84
8000	1.26	2.27	3.40	4.28	5.17	6.05	6.8	7.56	8.19	8.95	10.21	11.97	14.74	17.26	19.9	26.96	32.13	37.04	41.83
9000	1.29	2.32	3.48	4.39	5.29	6.19	6.96	7.74	8.38	9.16	10.45	12.26	15.09	17.67	20.38	27.6	32.9	37.92	42.83
10000	1.32	2.38	3.56	4.49	5.41	6.34	7.13	7.92	8.58	9.37	10.69	12.54	15.44	18.08	20.86	28.25	33.66	38.8	43.82
12000	1.37	2.47	3.7	4.66	5.62	6.57	7.4	8.22	8.9	9.73	11.1	13.02	16.03	18.77	21.64	29.32	34.94	40.28	45.48
15000	1.43	2.57	3.86	4.86	5.86	6.86	7.72	8.58	9.3	10.15	11.58	13.58	16.73	19.59	22.59	30.6	36.46	42.04	47.47

EXAMPLE—Required the amount of free air necessary to operate thirty 5-inch drills at 9,000 feet altitude, using to operate these drills air at a gage pressure of 80 pounds per square inch.

From Table I we find, when operating the drills at 80 pounds gage pressure at sea level, that one, 5-inch drill requires 190 cubic feet of free air per minute.

From Table II we also find that the factor for thirty drills at 9,000 feet altitude is 20.38; multiplying 190 cubic feet by 20.38 gives 3,872 cubic feet free air per minute, which is the displacement of a compressor for the above outfit under average conditions, to which must be added pipe-line losses, such as friction and leakage.

Globe Valves, Tees and Elbows

The reduction of pressure produced by globe valves is the same as that caused by the following additional lengths of straight pipe, as calculated by the formula:

$$\text{Additional length of pipe} = \frac{114 \times \text{diameter of pipe}}{1 + (3.6 \div \text{diameter})}$$

Diameter of pipe	1	1½	2	2½	3	3½	4	5	6	inches
Additional length	2	4	7	10	13	16	20	28	36	feet
	7	8	10	12	15	18	20	22	24	inches
	44	53	70	88	115	143	162	181	200	feet

The reduction of pressure produced by elbows and tees is equal to two-thirds of that caused by globe valves. The following are the additional lengths of straight pipe to be taken into account for elbows and tees. For globe valves multiply by $\frac{3}{2}$:

Diameter of Pipe	1	1½	2	2½	3	3½	4	5	6	inches
Additional length	2	3	5	7	9	11	13	19	24	feet
	7	8	10	12	15	18	20	22	24	inches
	30	35	47	59	77	96	108	120	134	feet

These additional lengths of pipe for globe valves, elbows and tees must be added in each case to the actual lengths of straight pipe. Thus, a 6-inch pipe, 500 feet long, with 1 globe valve, 2 elbows and 3 tees, would be equivalent to a straight pipe $500 + 36 + (2 \times 24) + (3 \times 24) = 656$ feet long.

Ingersoll-Rand Rock Drills used in the Construction of the Chinese Eastern Railway.

Loss of Pressure in Pounds by Friction in Transmission of Air Through Pipes 1000 Feet Long

Initial Air Pressure 60 Pounds Gage

Size Pipe	DELIVERY IN CUBIC FEET OF COMPRESSED AIR PER MINUTE																									
	9.84	14.73	19.64	24.60	29.45	34.44	39.35	49.20	58.90	68.6	78.6	88.4	98.4	118.1	137.5	156.6	176.5	196.4	294.5	393.7	492	589	686	786	884	984
	EQUIVALENT DELIVERY IN CUBIC FEET OF FREE AIR PER MINUTE																									
	50	75	100	125	150	175	200	250	300	350	400	450	500	600	700	800	900	1000	1500	2000	2500	3000	3500	4000	4500	5000
1″	18.24																									
1¼″	5.06	11.34	20.16																							
1½″	1.95	4.33	7.79	12.23	17.53																					
2″	.42	.95	1.69	2.65	3.80	5.17	6.77	10.61	15.20																	
2½″	.13	.29	.52	.81	1.16	1.58	2.09	3.24	4.65	6.31	8.28	10.47														
3″	.05	.11	.19	.30	.44	.59	.78	1.22	1.78	2.37	3.11	3.94	4.88	7.08	9.52											
3½″		.05	.08	.13	.19	.26	.36	.55	.78	1.07	1.40	1.77	2.20	3.17	4.29	5.57	7.08	8.77								
4″			.04	.07	.09	.18	.17	.27	.38	.53	.69	.88	1.08	1.56	2.12	2.75	3.49	4.33	9.73							
4½″				.03	.05	.07	.09	.15	.21	.29	.39	.48	.60	.87	1.17	1.52	1.94	2.40	5.39	9.65						
5″					.03	.04	.06	.08	.12	.17	.22	.28	.34	.49	.67	.87	1.17	1.37	3.08	5.51	8.61					
6″						.01	.02	.03	.05	.06	.08	.11	.14	.19	.27	.34	.43	.54	1.20	2.16	3.86	4.82	6.54			
7″							.01	.01	.02	.03	.04	.05	.06	.09	.12	.15	.19	.24	.55	.98	1.53	2.19	2.97	3.91	4.94	6.19
8″									.01	.01	.01	.02	.03	.04	.06	.08	.09	.12	.27	.41	.77	1.11	1.50	1.98	2.51	3.10
9″												.01	.01	.02	.03	04	.05	.06	.15	.27	.42	.61	.83	1.08	1.36	1.69
10″														.01	.02	.03	.03	.04	.09	.16	.25	.36	.48	.63	.79	.99
12″																.01	.01	.02	.03	.06	.09	.14	.19	.25	.32	.39
14″																		.01	.01	.03	.04	.06	.09	.11	.15	.18
16″																				.01	.02	.03	.04	.05	.07	.09

Initial Air Pressure 80 Pounds Gage

Size Pipe	DELIVERY IN CUBIC FEET OF COMPRESSED AIR PER MINUTE																									
	7.74	11.3	15.2	19.4	23.2	27.2	31.0	38.7	46.5	54.2	62.0	69.7	77.4	92.9	108.2	124.0	139.5	152	232	310	387	465	542	620	697	774
	EQUIVALENT DELIVERY IN CUBIC FEET OF FREE AIR PER MINUTE																									
	50	75	100	125	150	175	200	250	300	350	400	450	500	600	700	800	900	1000	1500	2000	2500	3000	3500	4000	4500	5000
1″	14.31																									
1¼″	3.96	8.46	15.31																							
1½″	1.53	3.26	5.92	9.64	13.79																					
2″	.33	.71	1.28	2.09	2.99	4.09	5.34	8.32	12.01																	
2½″	.10	.21	.39	.64	.91	1.25	1.63	2.54	3.67	4.99	6.53	8.25	10.81													
3″	.03	.08	.14	.24	.34	.47	.61	.96	1.38	1.88	2.45	3.13	3.83	5.61	7.46	9.86										
3½″	.01	.03	.06	.11	.15	.21	.27	.43	.62	.84	1.11	1.40	1.73	2.46	3.87	4.42	5.61	6.64	15.41							
4″		.01	.03	.05	.07	.10	.13	.21	.30	.41	.54	.69	.85	1.22	1.66	2.18	2.77	3.29	7.62	13.62						
4½″			.02	.03	.04	.06	.07	.12	.17	.23	.30	.38	.47	.68	.92	1.19	1.54	1.82	4.24	7.58	11.79					
5″			.01	.01	.02	.03	.04	.07	.09	.13	.17	.22	.27	.39	.53	.69	.88	1.04	2.48	4.32	6.88	9.72	13.25			
6″					.01	.01	.01	.02	.03	.05	.06	.08	.10	.15	.20	.27	.34	.40	.95	1.69	2.64	3.79	5.27	6.78	8.54	10.55
7″								.01	.01	.02	.03	.04	.05	.06	.09	.12	.15	.18	.43	.77	1.19	1.73	2.35	3.07	3.89	4.79
8″										01	.01	.01	.02	.03	.04	.06	.08	.09	.22	.39	.60	.87	1.19	1.55	1.97	2.46
9″													.01	.02	.02	.03	.04	.05	.12	.21	.33	.48	.65	.85	1.08	1.33
10″														.01	.01	.02	.02	.03	.06	.12	.19	.28	.37	.49	.66	.77
12″																.01	.01	.01	.02	.04	.07	.11	.15	.19	.25	.30
14″																			.01	.02	.03	.05	.06	.09	.11	.14
16″																				.01	.01	.02	.03	.04	.05	.07

For longer or shorter pipes the friction loss is proportional to the length; *i. e.*, for 500 feet one-half of the above, for 4,000 feet four times the above, etc.

Loss of Pressure in Pounds by Friction in Transmission of Air Through Pipes 1000 Feet Long

Initial Air Pressure 100 Pounds Gage

DELIVERY IN CUBIC FEET OF COMPRESSED AIR PER MINUTE (first header row)

EQUIVALENT DELIVERY IN CUBIC FEET OF FREE AIR PER MINUTE (second header row)

Size Pipe	6.41	9.61	12.81	15.81	19.22	22.39	25.62	31.62	38.44	44.78	51.24	57.65	63.24	76.88	89.56	102.5	115.3	126.5	192.2	256.2	316.2	384.4	447.8	512.4	576.5	632.4
	50	75	100	125	150	175	200	250	300	350	400	450	500	600	700	800	900	1000	1500	2000	2500	3000	3500	4000	4500	5000
1″	11.89																									
1¼″	3.29	7.42	13.20																							
1½″	1.28	2.87	5.11	7.75	11.42																					
2″	.27	.62	1.15	1.68	2.48	3.36	4.43	6.72	9.95	13.41																
2½″	.08	.19	.34	.52	.76	1.03	1.36	2.06	3.04	4.11	5.40	6.85	8.21	12.21												
3″	.03	.07	.12	.19	.29	.39	.51	.77	1.14	1.54	2.06	2.57	3.08	4.58	6.19	8.13	10.23	12.39								
3½″	.01	.03	.05	.08	.13	.17	.23	.35	.51	.69	.92	1.16	1.39	2.14	2.79	3.67	4.64	5.60	12.81							
4″		.01	.02	.04	.06	.09	.12	.17	.25	.34	.45	.57	.68	1.03	1.38	1.81	2.29	2.76	6.68	11.35						
4½″			.01	.02	.03	.04	.06	.09	.14	.19	.25	.32	.38	.57	.77	1.00	1.27	1.23	3.51	6.61	9.56	14.04				
5″				.01	.02	.03	.04	.05	.08	.11	.15	.18	.22	.33	.44	.57	.76	.88	2.03	3.62	5.51	8.11	10.95	14.48		
6″					.01	.01	.02	.02	.03	.04	.05	.07	.08	.12	.17	.22	.28	.34	.78	1.41	2.14	3.16	4.26	5.59	7.04	8.51
7″							.01	.01	.01	.02	.03	.03	.04	.05	.07	.10	.13	.16	.36	.67	.97	1.44	1.93	2.55	3.22	3.88
8″										.01	.01	.02	.02	.03	.04	.05	.06	.08	.18	.33	.49	.76	.98	1.30	1.84	1.98
9″												.01	.01	.02	.02	.03	.04	.04	.09	.18	.27	.39	.53	.72	.89	1.07
10″														.01	.01	.02	.02	.03	.05	.10	.16	.23	.31	.41	.52	.63
12″																.01	.01	.01	.02	.04	.06	.09	.12	.16	.21	.25
14″																			.01	.02	.03	.04	.05	.07	.09	.11
16″																				.01	.01	.02	.03	.04	.05	.06

Initial Air Pressure 125 Pounds Gage

DELIVERY IN CUBIC FEET OF COMPRESSED AIR PER MINUTE (first header row)

EQUIVALENT DELIVERY IN CUBIC FEET OF FREE AIR PER MINUTE (second header row)

Size Pipe	5.26	7.89	10.51	13.15	15.79	18.41	21.05	26.30	31.58	36.81	42.10	47.30	52.60	63.20	73.70	84.20	94.70	105.1	157.9	210.5	263.0	315.8	368.1	422.0	473.0	526.0
	50	75	100	125	150	175	200	250	300	350	400	450	500	600	700	800	900	1000	1500	2000	2500	3000	3500	4000	4500	5000
1″	9.88	22.20	39.50																							
1¼″	2.70	6.07	10.82	16.88	24.33	33.05																				
1½″	1.05	2.37	4.22	6.58	9.47	12.90	16.84	26.30	37.90																	
2″	.23	.51	.91	1.42	2.04	2.78	3.63	5.68	8.18	11.08	14.51	18.38	22.68													
2½″	.07	.16	.28	.43	.63	.85	1.11	1.73	2.51	3.39	4.44	5.61	6.95	10.00	13.60	17.80										
3″	.03	.06	.10	.16	.23	.32	.42	.65	.94	1.27	1.67	2.11	2.61	3.76	5.11	6.68	8.45	10.42	23.48							
3½″	.01	.03	.05	.07	.11	.14	.19	.29	.42	.58	.75	.95	1.18	1.69	2.31	3.01	3.81	4.71	10.59	18.81	29.40					
4″		.01	.02	.04	.05	.07	.09	.15	.21	.28	.37	.47	.58	.84	1.14	1.49	1.88	2.32	5.23	9.30	14.52	20.90	28.51			
4½″			.01	.02	.03	.04	.05	.08	.12	.16	.21	.26	.32	.46	.63	.83	1.04	1.29	2.90	5.15	8.05	11.59	15.78	20.61	26.10	32.20
5″				.01	.02	.02	.03	.05	.07	.09	.12	.15	.18	.27	.36	.47	.60	.74	1.65	2.94	4.60	6.63	9.01	11.80	14.90	18.45
6″					.01	.01	.01	.02	.03	.04	.05	.06	.07	.10	.14	.18	.23	.29	.64	1.15	1.80	2.59	3.58	4.61	5.83	7.20
7″								.01	.01	.02	.02	.03	.03	05	.06	.08	.11	.13	.29	.52	.82	1.18	1.61	2.19	2.65	3.27
8″										.01	.01	.01	.02	.02	.03	.04	.05	.07	.15	.26	.41	.60	.81	1.06	1.84	1.65
9″												.01	.01	.01	.02	.02	.03	.04	.08	.15	.23	.33	.45	.58	.73	.90
10″														.01	.01	.01	.02	.02	.05	.08	.13	.19	.26	.34	.43	.53
12″																.01	.01	.01	.02	.03	.05	.07	.10	.13	.17	.21
14″																			.01	.02	.02	.03	.04	.06	.08	.10
16″																				.01	.01	.02	.02	.03	.04	.05

For longer or shorter pipes the friction loss is proportional to the length; *i. e.*, for 500 feet one-half of the above, for 4,000 feet four times the above, etc.

THE EDDY PRESS CORPORATION
WINCHESTER, VA.

Stone Channeling Machines :: :: The Ingersoll-Sergeant Drill Company

Catalog No. 60 September, 1905

The Ingersoll-Sergeant Drill Company

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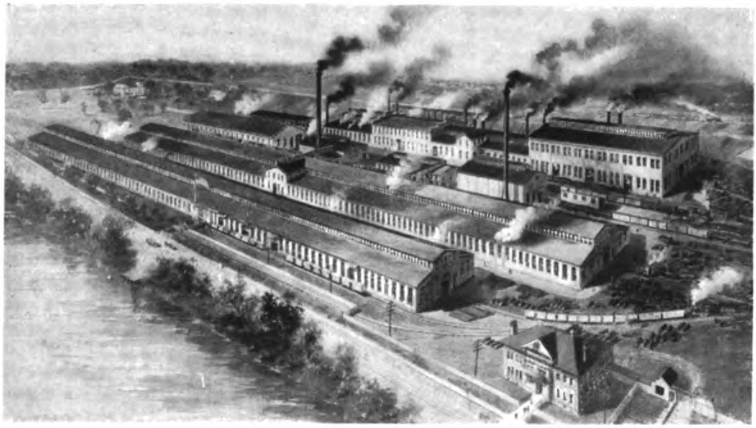

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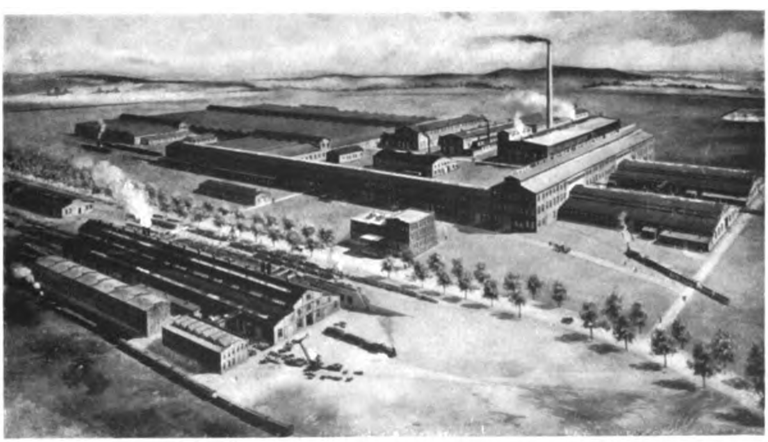
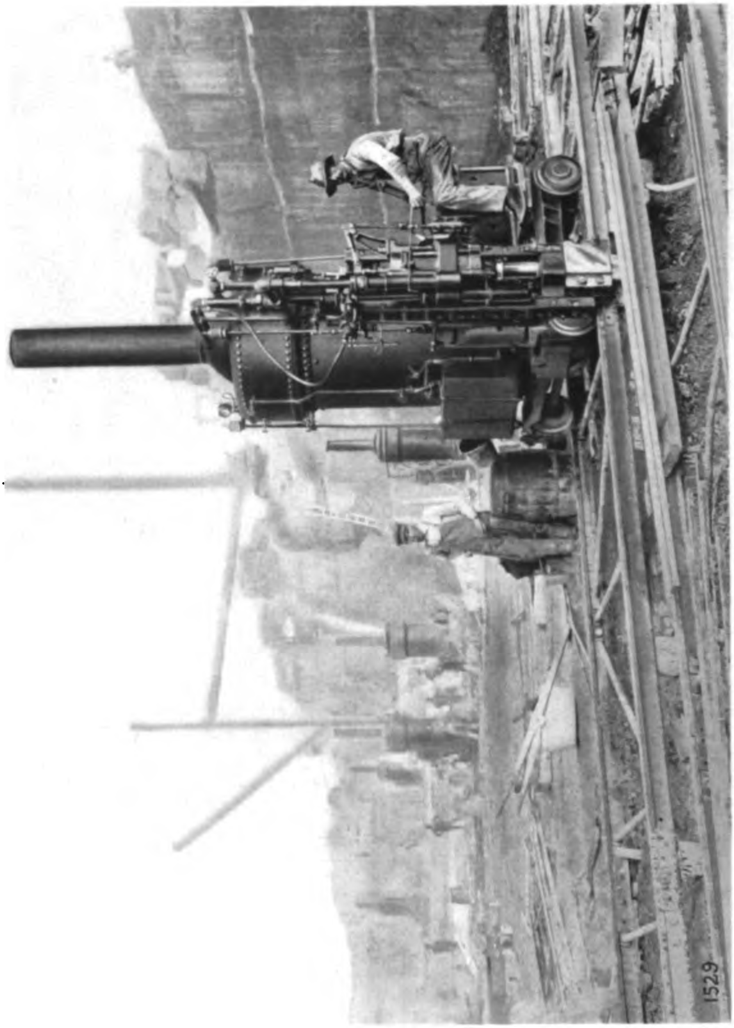


Manufacturing Plant of the Ingersoll-Sergeant Drill Co. at Phillipsburg, N. J.



Ingersoll-Sergeant "H 8" Track Channelers in operation in the Quarries at Bedford, Indiana.

Ingersoll-Sergeant Stone Channeling Machines

TWENTY years ago the Ingersoll-Sergeant Drill Company patented and placed on the market the first direct-acting stone channeling machine. It was an outgrowth of an extended experience in the building and operation of rock drills in all conditions of service. Its design was based upon the conviction that the same principles which had made the Ingersoll-Sergeant drill the best, would, properly applied, give the best results in cutting a channel. It was believed that the direct-acting machine possessed points of decided advantage over the slow, cumbersome diamond and lever types of rock-cutting machinery of that day.

The new channeler embodied these ideas of its designers, and though it was inevitable that certain shortcomings would appear in the first models, still it is an interesting fact that some of these first machines are in service to-day after more than fifteen years of continuous use and are still doing good work. The success of these pioneer types demonstrated beyond question the merit of the direct-acting principle now everywhere conceded as the correct one and it remained only to develop to the utmost the details of mechanical construction. With this idea in view, the performance of the machine was closely studied and the opinions of practical quarrymen combined with the judgment of the designers. As a result of this painstaking care the channeler has developed through the evolution of successive models, each better than the last; improvements have kept pace with the passing of years and the growth of experience; and the new Ingersoll track channeler as it stands to-day is practically a new machine from the rails up. In performance it has far outdone its forerunner; where the old machine cut 125 feet, the new channeler cuts 250 feet in the same time; in harder rock, where 90 feet was considered good for the old machine, 150 feet of channel is an average performance for the new model.

Not only have high power and cutting speed been secured, but endurance and reliability also have been given most careful

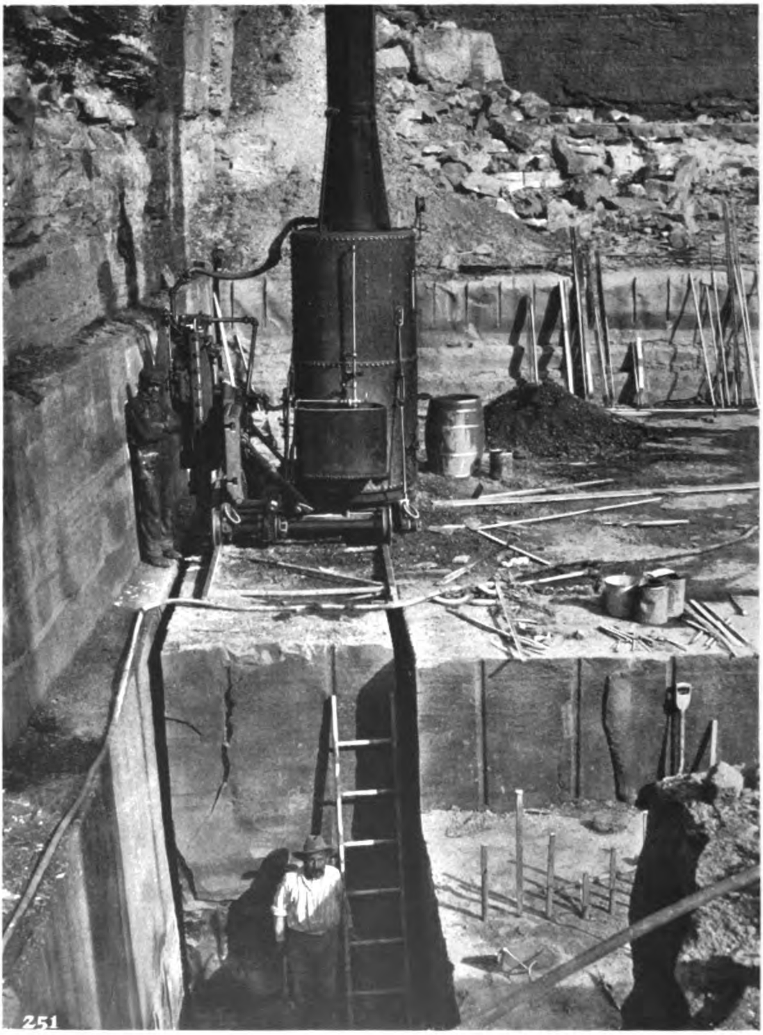
Quarrying with Ingersoll-Sergeant Track Channelers in the Indiana Oolitic District.

thought. The number of working parts has been reduced and the individual parts strengthened. Development in modern metals, toughened, hardened and made durable to the highest degree, has been an important feature in this advance. The questions of economy of fuel have been carefully studied and the inherent losses have been reduced to the limit. The result of all this care has been that the Ingersoll-Sergeant Track Channeler of to-day embodies in highest degree three qualities which have been found essential to success in continuous hard service:

Economy, Simplicity and Reliability.

To these inherent excellencies is added a great cutting speed, a tremendous capacity for hard work, which has made the performance of these channelers the standard of progress.

Opening up a Quarry in the Indiana Oölitic District
with Ingersoll-Sergeant Track Channelers



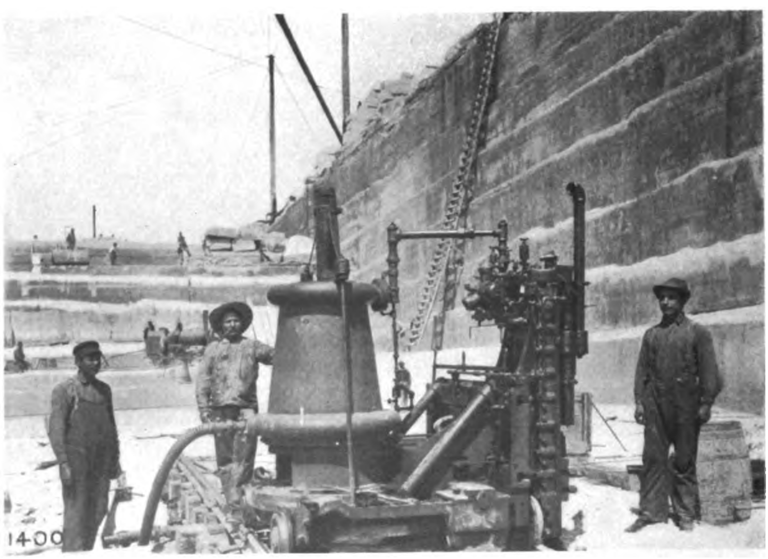
Channeling a 9-foot Key Block. This Ingersoll-Sergeant Track Channeler has been in constant use for over seventeen years.

The Field and Performance of the Ingersoll-Sergeant Fixed Back Channeling Machines

THE Ingersoll-Sergeant Fixed Back Track Channeler was designed primarily for the heaviest work and the deepest cuts, in open quarries of limestone, sandstone, slate and other materials, where the output is in dimension stone. In this service it has found its greatest field in making the long, deep, longitudinal cuts which are preliminary to further breaking by the plug and feather method.

This channeler has found another valuable field of application in certain classes of heavy contracting work, such as canals and reservoirs. The advantage of the track channeling machine in this work is threefold; first, the limits of excavation can be distinctly marked by channeling along the limiting line and shooting out within this mark; second, the quantity of rock to be broken and removed is confined strictly to the limits of cut—an item often of great consequence when competition is keen and prices low; third, the walls of the excavation are left smooth and solid, requiring the minimum of attention and maintenance. A notable instance of this canal work was seen in the Chicago Drainage Canal, where more than thirty Ingersoll-Sergeant track channelers of an earlier type were employed. The machines were also used in certain work in the enlargement of the Erie Canal and their performance was eminently satisfactory. At present a number of Ingersoll-Sergeant track channelers are employed on the new "Soo" Canal, in Michigan, while at the new dam of the Columbus (Ohio) Water Works, a track channeler of heavy type is being used to facilitate the removal of rock. These are instances showing the growing application of the track channeler as a part of the contractor's equipment. A peculiarity of this class of open-cut work with the channeling machine is that the firing of the blast at any level frequently shatters the material below that level. This remains to be cut on the next level and forces a very severe service upon the channeler—a service demanding a machine of great strength, high power and ready control. These conditions the "H8" and "H9" Track Channelers meet with greatest success.

The average cut with these heavy channeling machines is from eight to sixteen feet in depth, depending upon the nature of the stone. The gauge or width of the cut will depend upon the final depth sought. It may be from one and one-half to four inches at the start, reducing to a width of one and one-eighth inches with the last steels. The length of the channel is limited only by the length of track which can be used. Cutting speeds vary with the quality of rock and the handling of the machine. There are cases on record where the machine channeled 700 square feet in ten hours in oölitic limestone, during part of which time over 100 square feet per hour was cut. In Ohio sandstone of medium hardness, 260, 280 and 300 square feet per day of ten hours have been credited to the "H" channeler and these rates are being maintained as an average by the month. The average cost in this case runs from two and one-half cents to three and one-half cents per square foot cut. In other instances, runs under average conditions have repeatedly shown cuts of from 250 to 450 square feet of channel per shift of ten hours; the cost per square foot cut being in these cases from two to ten cents. On the Chicago Canal the cost was fifteen cents per square foot.

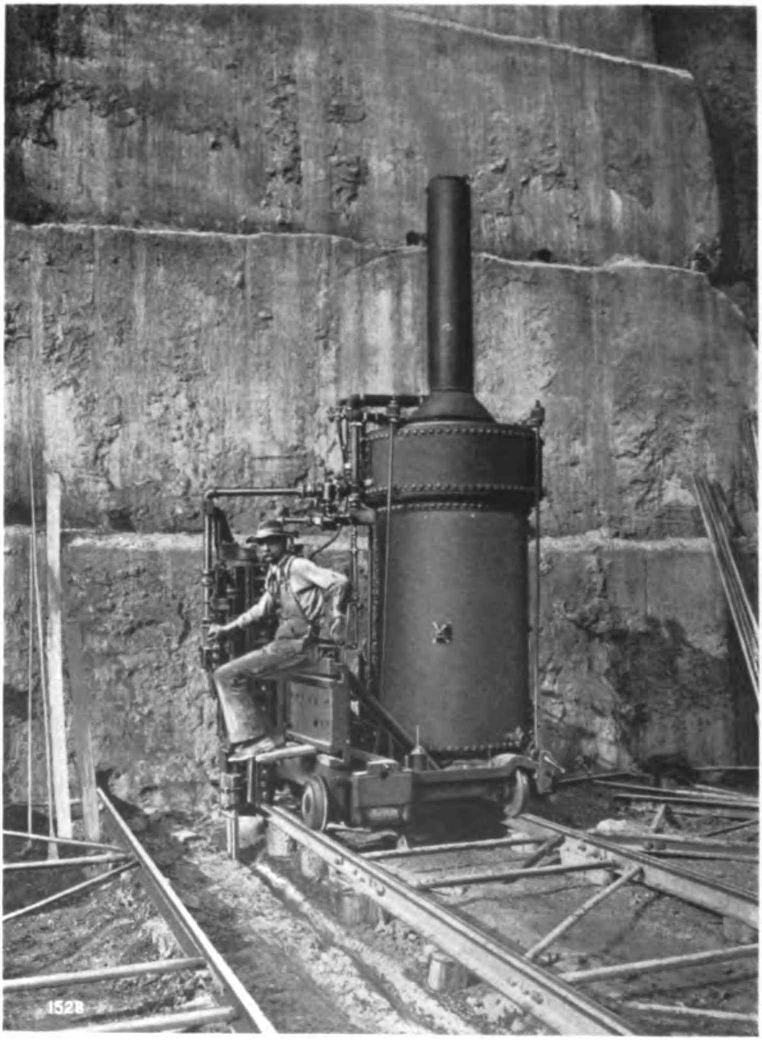


Ingersoll-Sergeant Track Channeler equipped with a Sergeant Reheater in the Grey Canon Quarry of the Cleveland Stone Company, North Amherst, Ohio.

The saving by the use of the machine channeler becomes apparent when the figures just stated are compared with the cost of hand methods applied to the same work, ranging from thirty to seventy-five cents per square foot. If to this saving in operating cost be added the further gain secured by the reduction of cutting waste, a still higher economy must be credited to the power channeler. Ordinary conditions of operation will require only two men on each channeler; and even in most arduous service four men to each machine will give all the attendance necessary. A channeling machine, with its attendants, considered as doing the work of drill men, wedgemen and trimmers, is easily the equivalent of thirty to forty men in work capacity; and the quality of its product is better than hand labor can produce.

The "H8" track channeler does good work under pressure of 85 to 95 pounds; and 110 to 125 pounds is the very highest pressure needed on any Ingersoll-Sergeant channeler. It is questionable if a pressure above this maximum gives results with any increase of economy over that of the lower pressure, for the repairs, difficulties of lubrication, etc., augment with high-pressure machines, beside increasing the difficulty with valves and connections. The use of the boiler on the truck makes the machine independent and self-contained; and in actual results per channeler better economy is secured than could be had from independent boilers. But the very highest economy in the quarry system as a whole can be attained only where the power from a central air-compressing plant is applied to the channeler through a reheater.

The Fixed Back Channeler is adapted for service in those quarries where the rock beds are horizontal or nearly so; and in such contracting work as requires only vertical rock facing. In open quarries the small offset or bench left by the channeler at each level is of no consequence, being simply worked away as the limits of the quarry increase. Nor is there any objection to these benches in canals or open cuts where only a few levels are needed to reach the desired depth. For working close up to end walls, the cutting engine is moved to either end of the frame by means of a pinch bar; the channel can thus be carried close up to both ends without turning the machine on its track.



An Ingersoll-Sergeant "H 8" Track Channeler in operation at Bedford, Indiana.

Ingersoll-Sergeant Fixed Back Channeling Machines Types "H8" and "H9"

THE Ingersoll-Sergeant Fixed Back Track Channeler is distinguished by a massive strength which is a guarantee of power and endurance. It is designed throughout for the heaviest and most severe service.

The general type is that of a truck mounted on four flanged wheels running on a track. Upon this truck is carried a boiler (in the steam-driven machine) or a reheater (in the air-driven channeler) together with a powerful chopping engine mounted at one side on a frame of great strength. Upon the end of the piston rod of this engine are mounted cutting steels which are driven against the rock by steam or air in the engine cylinder. For feeding the steels against the rock as the cut increases in depth, a second engine raises and lowers this cutting machine in its guides. A third engine, geared to the truck axles, moves the entire machine along the track. The resultant of these three motions—cutting, feed and travel—is a slot or channel in the rock, a few inches in width according to the gauge of steel, of a length limited only by the track travel, and of a depth determined by the length of steels used.

The direct-acting single-gang principle has demonstrated its preëminent superiority in years of varied service; it is retained in the Ingersoll-Sergeant channeler and its possibilities developed to the utmost. Piston and steels are in a straight line; power is applied to resistance in the most direct and positive manner, with the least possible loss in transmission. The blow is direct and powerful. The great weight of the channeler, together with its massive construction and rigid structure, absorbs vibrations, assures the highest mechanical efficiency, and gives a peculiarly effective cutting quality to the blow.

The design and construction of the new "H8" and "H9" Fixed Back Track Channelers are detailed at length in pages following. But for the benefit of those who seek the salient points of superiority without going into the minor essentials, the features are grouped here which distinguish these latest channelers, not only from earlier models of the same type, but also from contemporary machines of other makes.

Points of Superiority

Three powerful independent engines handling the three operative motions of cutting, feed and travel.

A piston tail-rod passing through the back head of the cylinder of the cutting engine, relieving wear on cylinder walls, avoiding broken piston rings, preventing cutting, removing binding strains, and maintaining perfect alignment of reciprocating parts. This is the only construction which provides for the great strains incidental to the constantly glancing blow consequent upon the chipping action of the bitts, and the still greater strains caused by neglect to promptly reverse at the end of the cut. Because of this feature the cylinders and piston parts outwear two to three sets of other makers.

A new positive valve mechanism driven from the piston tail-rod, elevated above the cylinder and secure from dust and mishap.

All joints bushed with hard steel in the valve mechanism, and provided with split adjustment, compensating for lost motion and preventing deranged valve action under long service.

A small flat auxiliary valve held to its seat under pressure, controlling the movement of the main valve, relieving the valve mechanism from the severe service of moving a large unbalanced main valve, and making the main valve action independent of the length of stroke. The auxiliary valve, being its under pressure, only tightens in service.

A perfect, yet adjustable, cushion at both top and bottom of stroke, using exhaust steam or air only, permitting the machine to work safely across seams, depressions and soft spots, or to cut in broken màterial.

Wholly-enclosed dust-proof three-cylinder reversible balanced engines controlling vertical feed of the cutting engine and track travel of the channeler, dispensing with all friction clutches, reversing gears and chain drives.

Telescopic joints in all piping, in lieu of the troublesome

swivel pipe joint with its inevitable leakage, discomfort and loss of power.

The extension of all controlling levers—for cushioning the blow, varying the feed and governing the travel—so as to be equally accessible from either end of the channeler when running.

Vertical guides for crosshead separately adjustable—top and side—in all directions, avoiding all lateral vibration and wear in the cutting engine, and made of the best metal for the purpose.

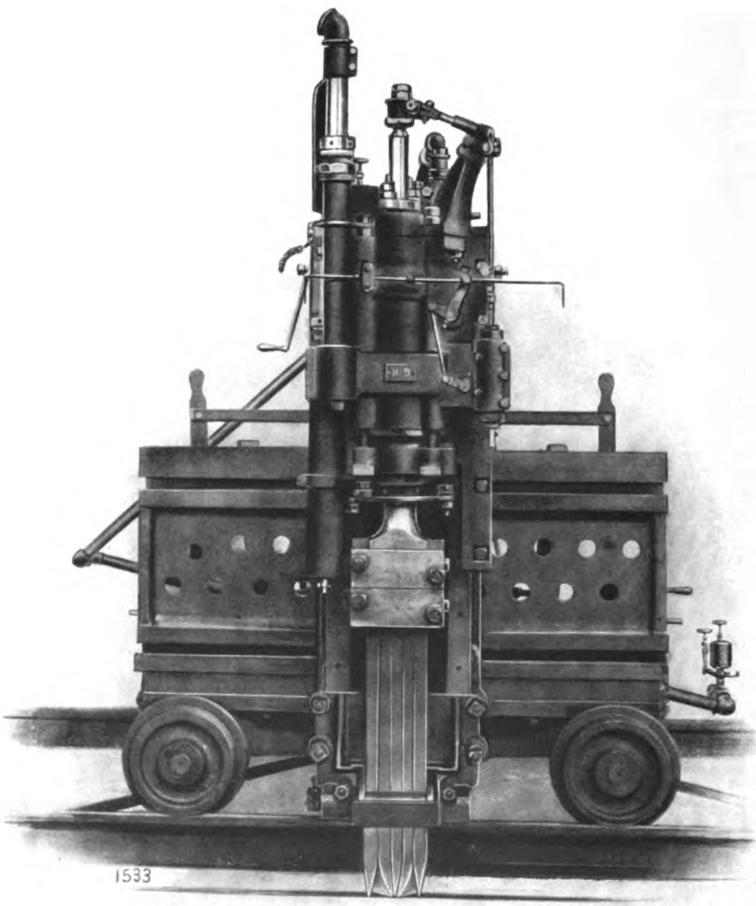
An adjustable feed nut, with long bearings, permitting an accurate taking up of wear, and avoiding lost motion.

Parts built throughout to limit gauges and strictly interchangeable. Parts are carried in stock at the different branch warehouses and may be had at once in emergencies. Very few parts are required, under reasonable freedom from abuse. These new models have all been thoroughly tested out by two to three seasons' hard service and have shown themselves remarkably free from repair costs and interruptions in service.

A design which admits of the best work with reasonably low and safe steam pressures, with easy firing and great economy in coal.

* * * * * * * * * *

These are some of the most distinctive features of the "H8" and "H9" Fixed Back Track Channelers. Their value will be appreciated by every one familiar with the requirements of channeler practice and the limitations which hamper the operation of other machines. The combination of these valuable elements in the present models has resulted in a **track channeler of highest power, maximum efficiency and greatest cutting capacity—a machine in which is united the maximum of effectiveness with the minimum of operative cost.**



Ingersoll-Sergeant "H 9" Track Channeler showing the Roller Guide in position. This Channeler may be equipped with a Crosshead and Solid Guides in place of Chuck and Roller Guides.

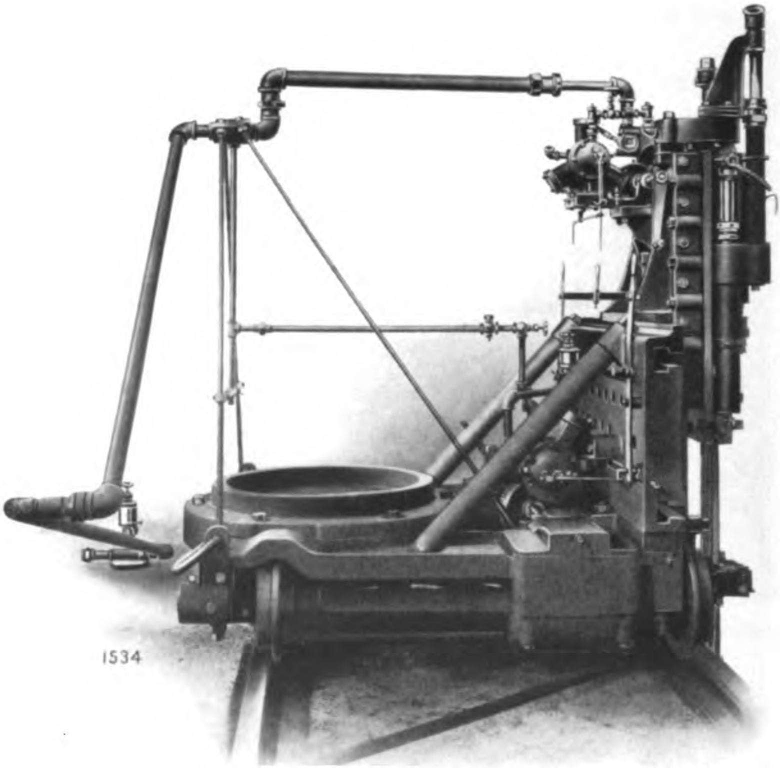
Details of Construction Ingersoll-Sergeant Fixed Back Channeler

Truck

THE channeler truck is a solid structure, ribbed and reinforced, bearing the entire weight of frame, engines, and boiler or reheater when used. The chilled cast truck wheels are keyed to the axles and the flange is of extra thickness to sustain the weight when the machine is off the track. The axles are of tough high-carbon steel, large in diameter and running in removable babbitted journal boxes. Collars prevent any lateral movement of the axles. Heavy straps and eyes receive the lifting bails by which the machine may be swung from a derrick. The center of gravity of the entire machine is low and the weight disposed to the greatest advantage, making the channeler run very steadily with less strain in moving over rough places.

Frame

The front frame upon which the cutting engine is mounted is a solid casting securely bolted to the truck at a planed joint. Strong diagonal steel rods passing through heavy cast tubes abut at a finished joint against lugs on frame and truck, bracing the frame with perfect rigidity. The advantage of a separate frame and truck as compared to a single solid casting is that the possible weakness arising from shrinkage strains in a large and difficult casting is avoided; furthermore, the arrangement permits a higher front frame, giving better support for the cutting engine and relieving the guide shell from buckling strains. The frame has a finished surface on the front face and the upper edge, upon which bears the guide shell. A heavy shoulder on the latter hooks over the frame and sustains the weight of the engine, shell and steels. Strong steel bolts traveling in T slots in the frame secure the shell in position at any point between the two extremes. The shell and engine is moved from point to point by means of a pinch bar inserted in holes in the frame. The shell has a wide bearing surface upon the frame, with a consequently reduced tendency to spring and bind in action.



Side View of the Fixed Back Channeler showing the Guide Shell and the Three-Cylinder Engines for Feed and Travel.

Guide Shell

The shell upon which the cutting engine slides is a strongly ribbed casting having a wide bearing on the frame, to which it is secured as just described. Two separate sets of guides—front and side—are provided, accurately surfaced, independently adjustable and secured to the shell by heavy bolts. Adjustment is thus provided in two directions; wear is taken up by the use of shims or liners, and perfect alignment maintained without any lateral vibration and exaggerated wear. The guides for the cutting engine and the cross-head are separate and independent—another refinement providing for possible unequal wear in these two parts.

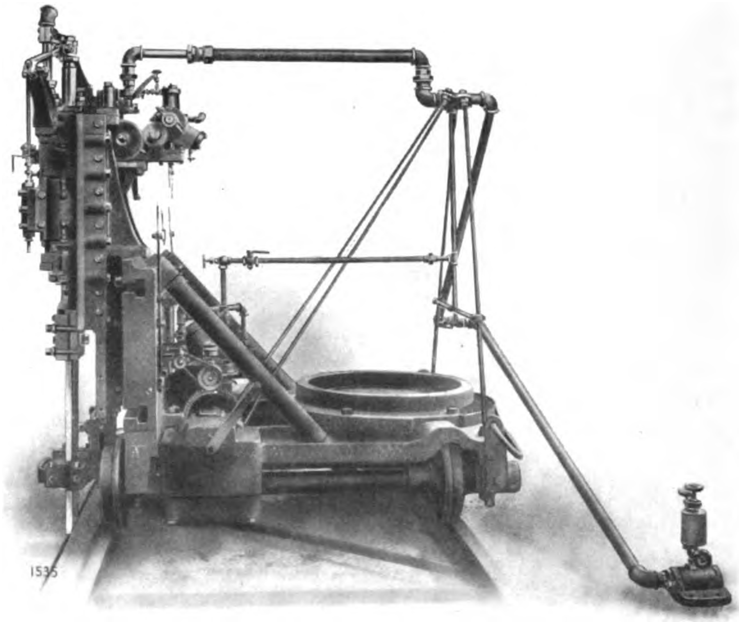
Feed Engines

The engines for feed and travel are of standard Ingersoll-Sergeant three-cylinder balanced type, self-contained and wholly enclosed. These machines have been redesigned throughout and strengthened over former models. Their power has also been increased. Crank pins, connecting rods and shaft have been enlarged, bearings lengthened and cylinder diameters increased, and pistons fitted with improved steam-tight rings. The details have been carefully studied and the result is an engine of high efficiency, great reliability, perfect balance and minimum dimensions. Crank parts run in an oil bath which also floods the bearings. The engines are reversible and are started and stopped, speeded or reversed, by a single lever.

Ingersoll-Sergeant Three-Cylinder Engine

Track Feed

Worm gearing communicates motion from the track travel engine to the truck axles; every wheel is a driver. Bronze worm wheels, securely clamped on each axle between heavy cast-iron collars, mesh with worms of high carbon steel, keyed to a steel driving-shaft turning in babbitted bearings. The track feed engine is mounted midway between the axles and drives the worm shaft through cut gears. The reversible engine dispenses with the annoyance of reversing gears or friction clutches. The worm gearing on both axles is fully enclosed in a dust-proof iron box which also serves as an oil bath in which the wheels dip. A sheet steel hood protects the engine and reducing gears. The worm shaft is squared at both ends to receive a crank by which the channeler may be moved by hand. The engine controlling lever is brought up and extended so as to be within reach of the operator from either end of the channeler. In addition to this lever control, a throttle valve is inserted in the supply pipe, and a governor limits the speed of the engine.



Showing the Side of the "H 9" Track Channeler. Three-Cylinder Engine Raising and Lowering the Main Cutting Engine.

Vertical Feed

The raising and lowering of the main cutting engine is provided for by a second three-cylinder engine, mounted on a bracket cast solid with the shell, and geared to the feed-screw through a worm shaft and cut steel reducing gears. This engine also is separately controlled by a single lever reached from either end of the machine; a valve in the supply pipe affords further protection. Hand feed is provided by a crank at either end of the feed worm shaft. The feed-screw worm wheel, of bronze, is keyed in place and meshes with a cut feed-worm of high carbon steel keyed on a spindle turning in brass-bushed bearings. The feed-screw is of high carbon steel, oil-treated and toughened, with a threaded portion of unusually large diameter cut to Acme standard. End thrust is borne by generous brass bushings carried in heavy lugs on the shell. The long bronze feed-nut is made in two parts, with a micrometer adjustment for wear and lost motion, this greatly increasing the life of nut and screw.

Cutting Engine

The main cutting engine has a heavy, strong cylinder, with guide lugs and clamps for the feed nut integral parts of the casting. Heads join the cylinder at ground joints and are held in place by heavy through-bolts of steel. The steam branch-pipe is a box casting fastened to the top of the shell and piped direct to the source of pressure. A ground pipe working in a stuffing box gives telescopic connection between this branch pipe and the main port of the cylinder. A similar telescopic section in steam-driven machines delivers the exhaust to the stack of the boiler. Two straightway throttle valves control the supply and are of a new model in which pressure holds the plug to a close seat.

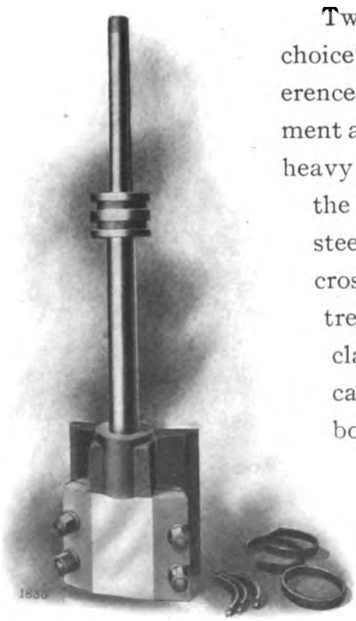
Valve Motion

Two valves, main and auxiliary, regulate the supply of air or steam to the cylinder. The main valve is a plunger-guided D-valve thrown by unbalanced pressures and bearing on a surfaced seat-plate. The auxiliary valve is a small D-valve held to its seat by pressure and operated through a telescopic lever from the tail-rod of the piston. The function of the auxiliary is simply to control the admission of pressure which throws the main valve. Its preëminent advantage lies in the fact that it relieves the valve mechanism from the severe duty of moving a heavy unbalanced main valve. It furthermore makes the main valve action independent of the length of stroke of the machine. Ports are unusually large and free. The valve action is quick and positive, and full pressure is instantaneously admitted to the piston. The valve mechanism is elevated well above the cutting engine, safe from dust and accidental injury. Its cast elements are of steel or gun-metal; all machined parts are of oil-treated high-carbon steel; bearings and joints have split adjustment with removable steel bushings. This last feature is a refinement which maintains the valve action at point of highest economy in long service. Cushion valves control and regulate compression at both ends of the stroke, exhaust steam or air only being used in this process. The cushion lever is extended to both sides of the machine, and by a small movement the lightest cushioned blow may be struck or full power delivered.

Piston

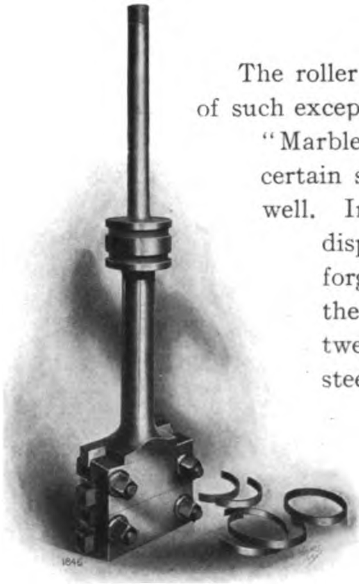
Piston, rod, and tail-rod are forged solid from a billet of high-carbon steel, oil-treated, annealed and ground true. The piston head is extra long and carries two sets of heavy new-style segmental rings forced outward by a flat spring. The tail-rod extends through the back cylinder head and operates the valve mechanism; it further serves the important functions of a back piston guide. This is a most important feature, for the reciprocating element of the channeler is the most vulnerable part and is subjected to the most severe service. The back piston guide maintains perfect alignment, relieves binding strains and avoids grooved cylinders, broken piston rings and shattered piston rods.

Cross-Head


Cross-head for Solid Guides.

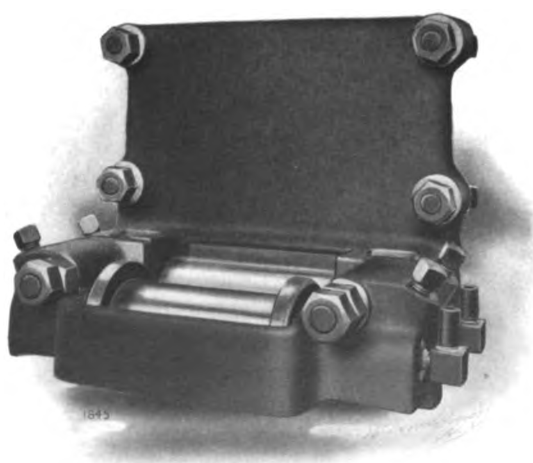
Two styles of guides are offered, the choice being left largely to the personal preference of the buyer. Under one arrangement a heavy cross-head is provided, being a heavy steel casting driven to a taper fit on the piston rod. This receives the cutting steels held in place by the clamp. The cross-head clamp is a steel forging, oil-treated, annealed and machined. The clamp bolts are extra heavy and of high-carbon steel; the adoption of a swing bolt at this point saves much valuable time in changing steels. The cutting steels abut directly against the cross-head and are held rigidly by the wide clamp contact. The whole device bears in ample guide surfaces in the lower portion of the shell.

Roller Guide

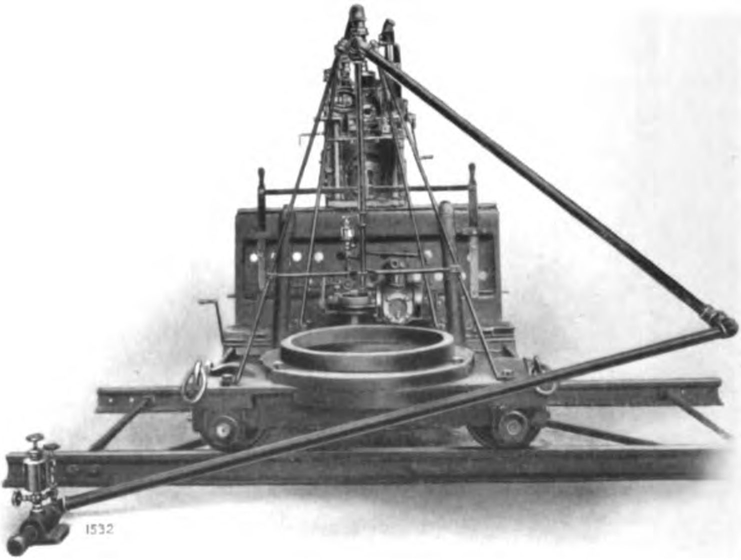


Chuck used with the Roller Guide

The roller guide is a later device which proved of such exceptional value on the "Broncho" and "Marble" Channelers that it was applied for certain service on the heaviest machines as well. In this arrangement the cross-head is dispensed with entirely and a chuck, forged solid with the piston rod, receives the cutting steels. The bits work between two guide rollers of hardened steel, guiding them on all four sides. This relieves the machine from the weight of the heavy cross-head and the friction of the cross-head guides; the friction of the steels in the rollers is practically negligible. With this device a split front head is required, held in place by a strong forged steel ring drawn on a taper by the cylinder through-bolts. In changing steels, one or two bolts are loosened and the front roller lifted away, when the steels may be cleared. The guide rollers are mounted on a plate which can be raised or lowered on the shell of the machine. The use of the roller guide permits the machine to strike a more rapid blow, and increases its cutting power and capacity in material somewhat springy or elastic in nature. In "mud cuts" the heavy cross-head is undoubtedly an advantage—in free cuts the roller guide may give the best results.



The Roller Guide



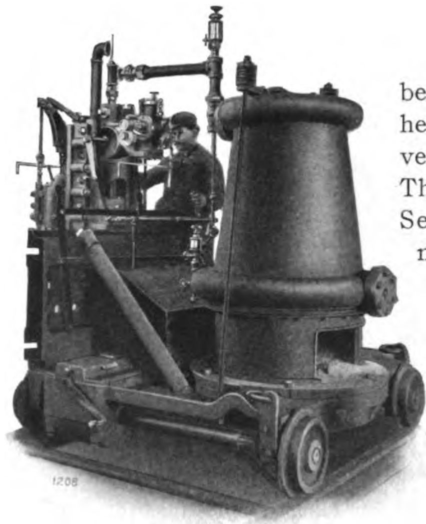
Back of a Fixed Back Track Channeler showing Piping, Braces and Stays.

Piping

Each of the three engines on the track channeler have independent piping from the source of pressure and any one may be cut out without affecting the other two. Pipe and fittings throughout are *extra heavy*, everywhere well braced and stayed. Wherever flexibility is required, telescopic joints and stuffing boxes are used instead of the old-style swivel joint with its troublesome leakage. Cylinder lubrication is provided by a sight feed lubricator on the main supply pipe.

Boiler

Boilers are of the vertical submerged flue type, with the shell extended at the top to give a large steam chamber. The material is flange steel of 60,000 pounds t. s., properly stayed and braced. Each boiler is tested by hydrostatic test and built for a working pressure of 150 to 200 pounds. Hand holes give ready access for inspection and cleaning. The boiler is a quick and economical steam-maker and requires a minimum of repairs. The fittings supplied include steam and water gauges, injector, water tank, safety valve and fire tools.



An "H 8" Fixed Back Track Channeler equipped with an Air Reheater of the Sergeant type.

Reheaters

When compressed air is to be the source of power, a reheater is supplied where the very highest economy is sought. This is of one of the standard Sergeant types, giving the maximum heating effect with a small fuel consumption. A very small quantity of fuel used in these reheaters will reduce the volume of free air required by the machine from 20 to 25 per cent., as compared with that demanded when cold air is used.

Track

The standard track equipment furnished with each channeler provides for a total length of forty-two feet, in three sections of twelve feet and one of six feet. Standard 80-pound rail is used and gauge is maintained by the use of heavy forged distance pieces, with diagonal braces of the same stock. This stiff, solid track now provides for the minimum of blocking, without vibration.

Equipment

The equipment with each "H8" and "H9" machine is as follows:

One tool chest, containing shims, hatchet, hammer, wooden level, steel square, three files, cold chisel, hand saw, twenty-one wrenches, waste, packing, crosshead clamp, keys, bolts, nuts and washers; seat, step, lifting bails, three 12-ft. sections of track, one 6-ft. section of track, splice bars, bolts, nuts and pins; adjustable square, wooden straight edge, steel bar, chest of wooden track blocks, iron bar, scoops, scrapers, gauge for bits, one set of steels (see page 28); lubricators, oil cans, steam cylinder oil, machine oil, piston ring entering band, and hooks.

When a boiler is used, the equipment also includes a slicer, hoe and poker.

Steels are furnished according to the stone to be channeled, as follows:

Steels for Marble and Limestone When Used with Crosshead

Fifty pieces of steel constitute two sets (10 gangs, 5 pieces to each gang), to channel to a depth of 7 ft. in marble and limestone. Size of steel, 7/8 in. by 1½ in.

2	Gangs—10	pieces,	each	1 ft. 6 in.	long.
2	" —10	"	"	3 ft.	"
2	" —10	"	"	4 ft. 6 in.	"
2	" —10	"	"	6 ft.	"
2	" —10	"	"	7 ft. 6 in.	"

The Blacksmith's Gauge for Steels for Marble and Limestone, commences at 1½ in. and reduces 1-16 in. on each length from the 3-foot lengths up. The starters and the 3-foot lengths have the same gauge, 1½ in.

All gangs of the same length have the same gauge.

Steels for Sandstone When Used with Crosshead

Thirty pieces constitute two sets (10 gangs, 3 pieces to each gang), to channel to a depth of 7 ft. in sandstone. Size of steel, 7/8 in. by 2½ in.

2	Gangs—6	pieces,	each	1 ft. 6 in.	long.
2	" —6	"	"	3 ft.	"
2	" —6	"	"	4 ft. 6 in.	"
2	" —6	"	"	6 ft.	"
2	" —6	"	"	7 ft. 6 in.	"

The Gauge for the Sandstone Bits commences at 3 in. and reduces ¼ in. on each length from the 3-foot lengths up. The starters and the 3-foot lengths have the same gauge, 3 in.

All gangs of the same length have the same gauge.

Steels for Marble and Limestone When Used with Roller Guide

Fifty pieces of steel constitute two sets (10 gangs, 5 pieces to each gang), to channel to a depth of 7 ft. in marble or limestone.

Each gang uses 3 steels 1 in. by 1⅜ in. and 2 steels 1 in. by 1¼ in.

2	Gangs—10	pieces,	each	2 ft. 6 in.	long.
2	" —10	"	"	4 ft.	"
2	" —10	"	"	5 ft. 6 in.	"
2	" —10	"	"	7 ft.	"
2	" —10	"	"	8 ft. 6 in.	"

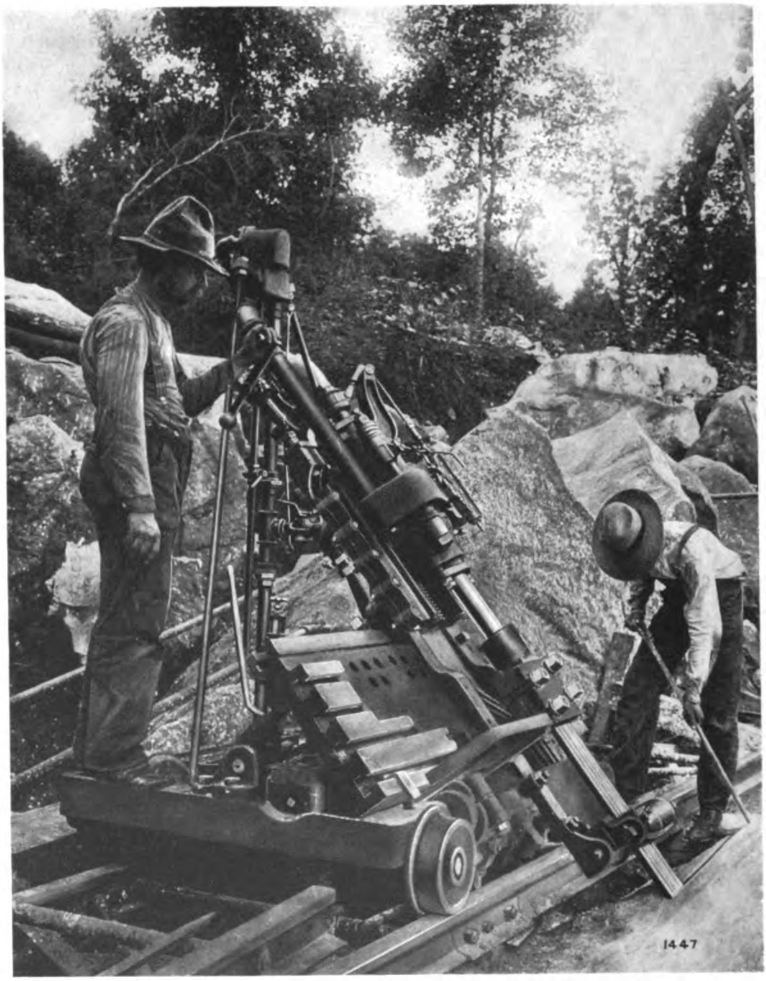
NOTE.—It will be noticed that these steels are longer for a given depth of cut than when a crosshead is used, but this extra length is used by Roller Guide.

The Blacksmith's Gauge for Steels for Marble and Limestone commences at 1½ in. and reduces 1-16 in. on each length from the 4-foot lengths up. The starters and the 4-foot lengths have the same gauge, 1½ in.

Specifications of Ingersoll-Sergeant Channelers

SIZE AND TYPE		Fixed Back Channeler "H8"	Fixed Back Channeler "H9"	Swing Back Channeler "H9"	Swing Back Channeler 6 in.	Swing Back Channeler 5 in.	Undercutting Channeler	Broncho Channeler
Diameter of Cylinder	in.	8	7	7	6	5	3½	3½
Length of Stroke	in.	9	9	9	6½	6½	7	6½
Distance of Cut from Vertical Wall	in.	7¼	7¼	7¼	7¼	5	8½ (lift)	
Distance from Center to Center of Cut with Machine Reversed	ft. in.	7 - 0	6 - 0⅝	6 - 8⅝	4 - 7⅝	4 - 6⅝		
Inside Gauge of Track	ft. in.	5 - 3	4 - 4⅝	4 - 4⅝	3 - 0⅝	3 - 0⅝	4 - 0⅜	
Length over all	ft. in.	5 - 3	5 - 3	5 - 2	5 - 5	5 - 5	5 -10½	14 - 0
Width over all — Without Boiler	ft. in.	7 - 1	7 - 0½	7 - 4½	5 - 5	5 - 2	8 - 3	2 - 6
Width over all — With Boiler	ft. in.	7 - 6½	7 - 6	7 -10				
Width over all — With Reheater	ft. in.	7 - 3½	7 - 3	7 - 7				
Height — Without Boiler	ft. in.	7 - 4	7 - 4	7 - 2	6 -10½	6 -10½	2 -10	6 - 0
Height — With Boiler	ft. in.	10 - 0	10 - 0	10 - 2				
Height — With Reheater	ft. in.	7 - 4	7 - 4	7 - 2				
Weight of Channeler alone — Without Boiler	lbs.	9,000	9,000	8,000	5,150	4,850	6,800	2,375
Weight of Channeler alone — With Boiler	lbs.	12,900	12,900	11,900				
Weight of Channeler alone — With Reheater	lbs.	10,300	10,300	9,300				
Total Shipping Weight with Track and Equipment — Without Boiler	lbs.	† 13,900	† 13,900	13,700	† 10,500	† 10,200	† 11,800	‡ 3,500
Total Shipping Weight with Track and Equipment — With Boiler	lbs.	† 17,875	† 17,875	17,675				
Total Shipping Weight with Track and Equipment — With Reheater	lbs.	† 15,175	† 15,175	15,000				
Code Word — Without Boiler	lbs.	VOERLABADO	VOERLABBIO	VOERLABODA	VOERLABRA	VOERLABRED	VOERLACAIT	VOERLACAL
Code Word — With Boiler	lbs.	VOERLABAIS	VOERLABEGA	VOERLABOS				
Code Word — With Reheater	lbs.	VOERLABARE	VOERLABEM	VOERLABOUR				

*Height is from top of rail to top of boiler hood which does not include stack.
†These weights are for domestic shipment. Add 1000 lbs. for foreign shipment.
‡This weight is " " " " 200 " " " "



Swing Back Type of Ingersoll-Sergeant Track Channeler as illustrated in the 5-inch "Marble" Channeler.

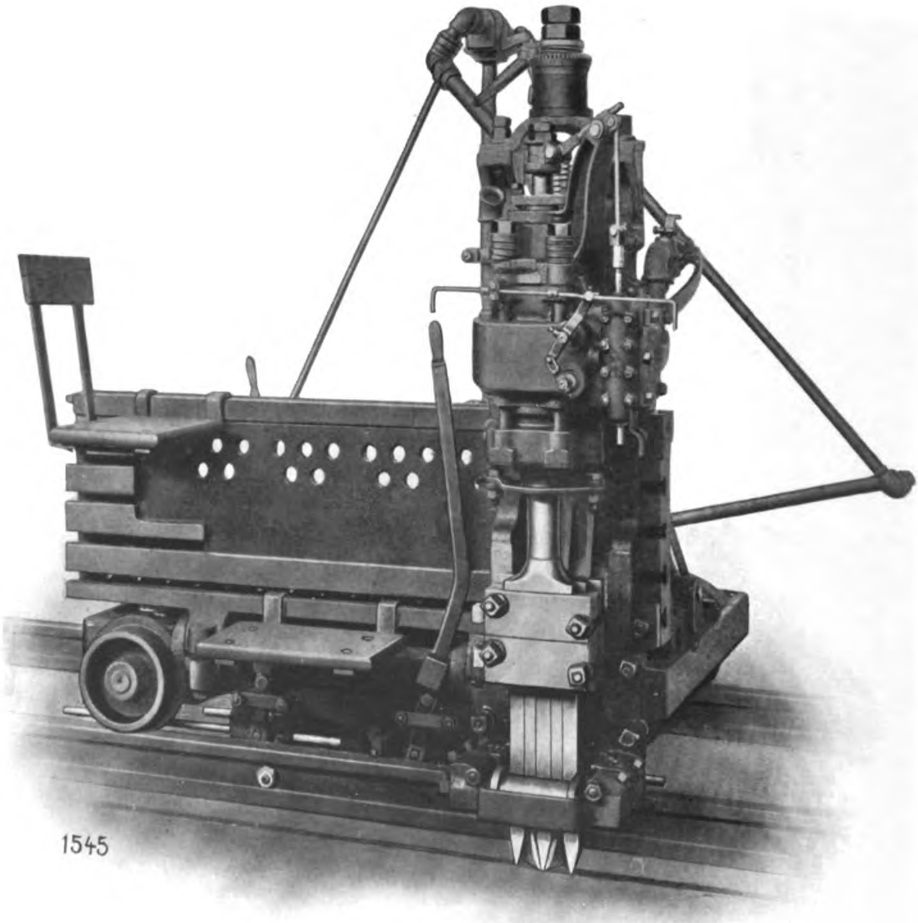
Ingersoll-Sergeant Swing Back Track Channelers

IN the Fixed Back Channeler the movement of the steels is limited to two vertical planes and the cut made is vertical with square ends. The field of the fixed back machine has been already defined. But there are other conditions which demand a greater adjustability.

The Swing Back Track Channeler is intended for angular cutting in quarries where the floor is to be enlarged, or where the formation dips or inclines and it is desirable to follow it without removing the overlying rock. Under these last conditions it is still necessary to channel at right angles to the rift of the rock bed and the swinging frame makes it possible to make the proper angular adjustment. The swing of the cutting engine around a trunnion, in the plane of the frame, permits adjustment for transferring cuts and working up into corners.

In machines of this type the frame carrying the cutting engine swings on a hinge joint, giving an angular adjustment up to forty-five degrees from the vertical in the bare machine, or fifteen degrees in the machine carrying a boiler or reheater. In addition to this movement, the cutting engine itself swings in the plane of the frame, with an angular range up to forty-five degrees either side of the vertical.

The cut on the opposite page illustrates one of these Swing Back Channelers. Details of size, capacity and construction are furnished on application.



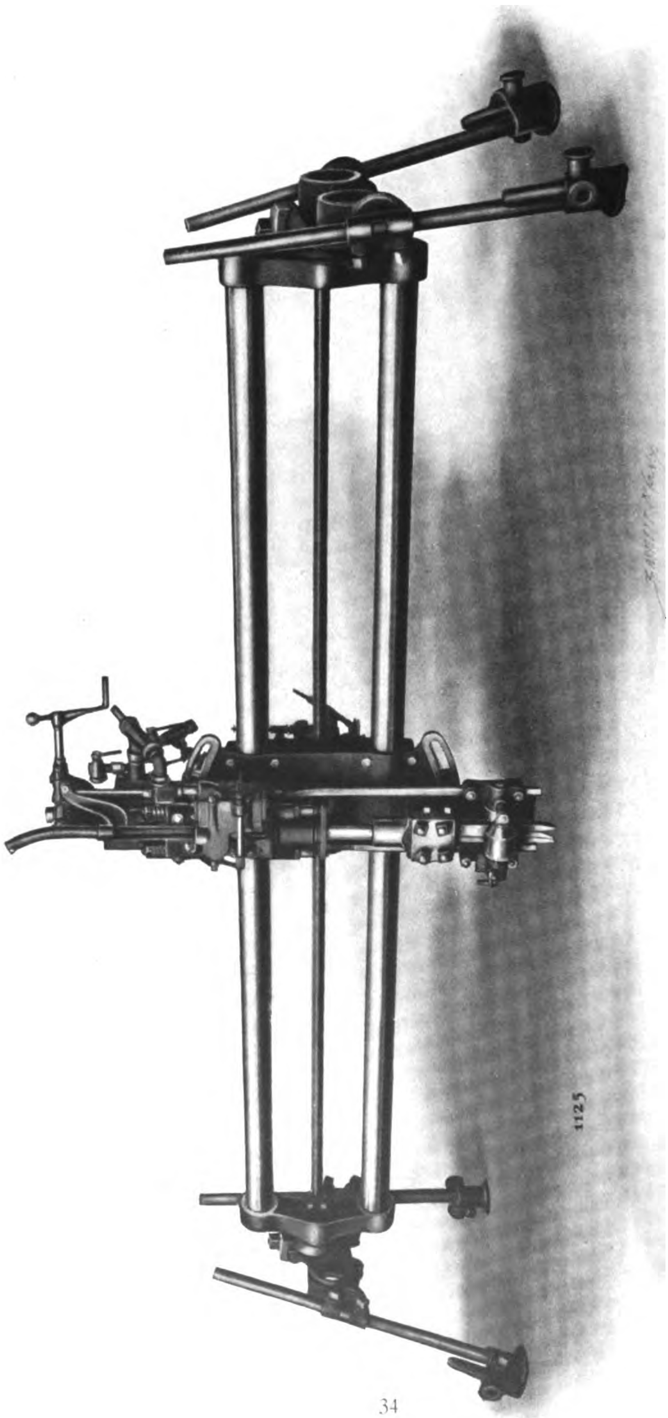
Ingersoll-Sergeant "Marble" Track Channeler
of the 6-inch size.

Ingersoll-Sergeant "Marble" Track Channelers

THE requirements of marble channeling are peculiar. The rock will not stand the powerful blow of the heaviest machines, for it shatters out of the line of the cut under the heavy impact. Furthermore the marble deposits are found at all angles, necessitating in a machine for channeling a wide adjustability and light weight.

It is to meet these characteristic conditions that the Ingersoll-Sergeant Drill Company has developed a small channeler, which has been given the distinctive name of the "Marble" Channeler. While the general principle of the heavier track machines has been retained, including the direct-acting single-gang type and the methods of feed and travel, yet important details have been changed to meet the peculiar demands of the service. The machine is light and easily moved, yet strong and reliable; the methods of control are convenient and effective. Since one of the strong features of the "Marble" Channeler is its great adaptability to inclined deposits, it is of necessity a swing back type; and that full advantage may be taken of its adjustability, it is never equipped with a boiler or reheater, but takes its power through a flexible arrangement of piping.

These machines have established a record in the last few years, in the marble fields of Vermont, Tennessee and other districts. In daily service under all conditions they have shown a cutting capacity one-quarter to one-third greater than any other marble channeler. Their correctness of principle, their superiority in design, material and workmanship, their endurance under hard service, are recognized by all users. These qualities, together with their universal adaptability to marble of all grades and deposits at all angles, have won for the "Marble" Channeler a wide sale and a leading place in the marble industry.



The "Broncho" Channeler.

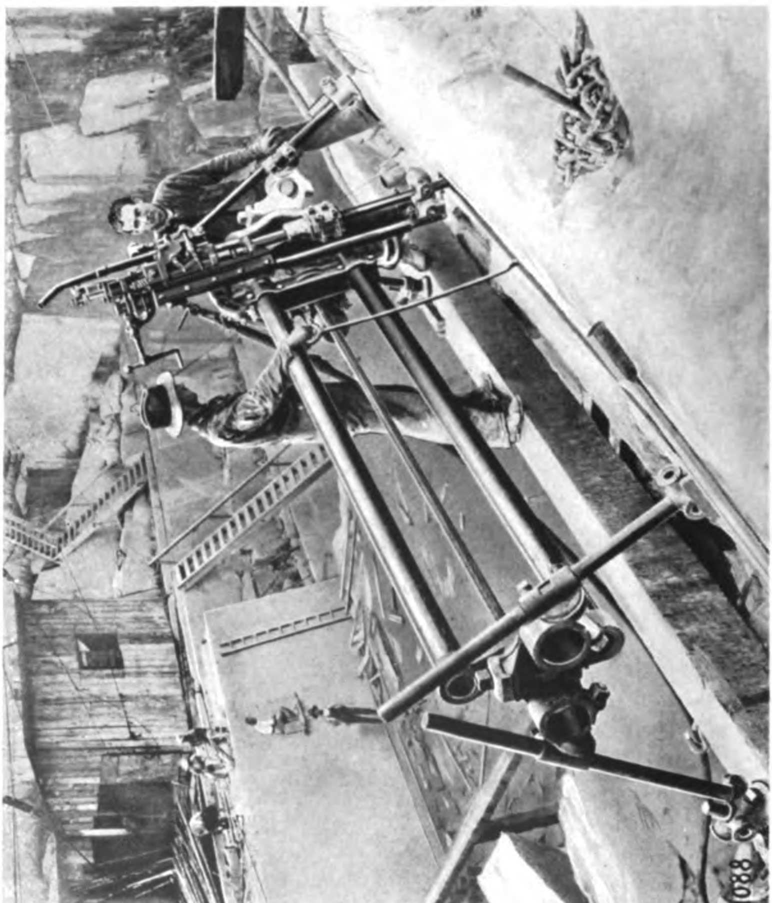
The Ingersoll-Sergeant "Broncho" Channeler

AS the knowledge of stone channeling methods has extended, the need has become apparent for a channeling machine intermediate in its functions and capacity between the heavy track channeler on the one hand and the light quarry bar with its drill on the other.

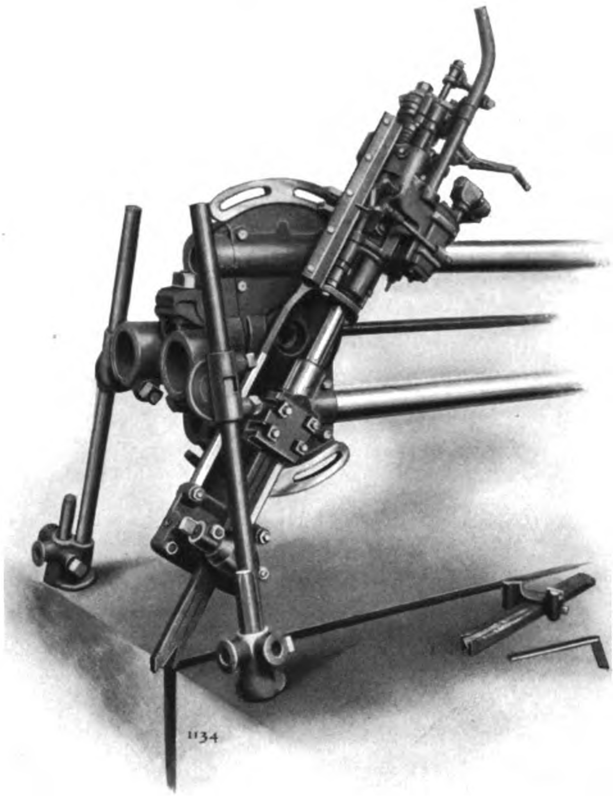
The Ingersoll-Sergeant "Broncho" Channeler is such a machine. It is a light, powerful, efficient channeling engine suited for a wide range of work in quarries in all materials. It has also found a valuable place in certain classes of contract work, as in trench excavation.

The powerful track channeler has its proper field in heavy rock work, doing rapid, cheap cutting, making long and deep cuts, in any grade of material, however difficult. But there are many cases in which the lighter and cheaper "Broncho" Channeler will be found fully as effective, yet more economical and satisfactory in its operation. For instance, on deposits having a sharp dip or incline, the track channeler is impracticable. The "Broncho," on the contrary, with its light, flexible, sturdy mounting and easy adjustment, is peculiarly fitted for these difficult conditions. In opening up new quarry properties, this lighter machine provides a ready and rapid means of "proving up" the value of the deposit, without going to the heavy initial outlay for a more powerful cutting equipment. In this case its use spares the expense of a permanent outfit of greater capacity until the property has been placed upon a paying basis of production. In established quarries, the machine proves a most valuable adjunct to the heavier channelers when used for cutting sumps, removing key blocks, and enlarging the walls. It is particularly useful and effective in confined spaces and on irregular surfaces.

While the "Broncho" is an outgrowth of the experience gained with the bar channeler, it is in no way to be compared with this earlier device. Lessons learned in the use of the lighter machines have resulted in the distinctive features of design which give the new channeler a greatly increased power, speed, capacity and adaptability, and which mark it as an entirely new type.



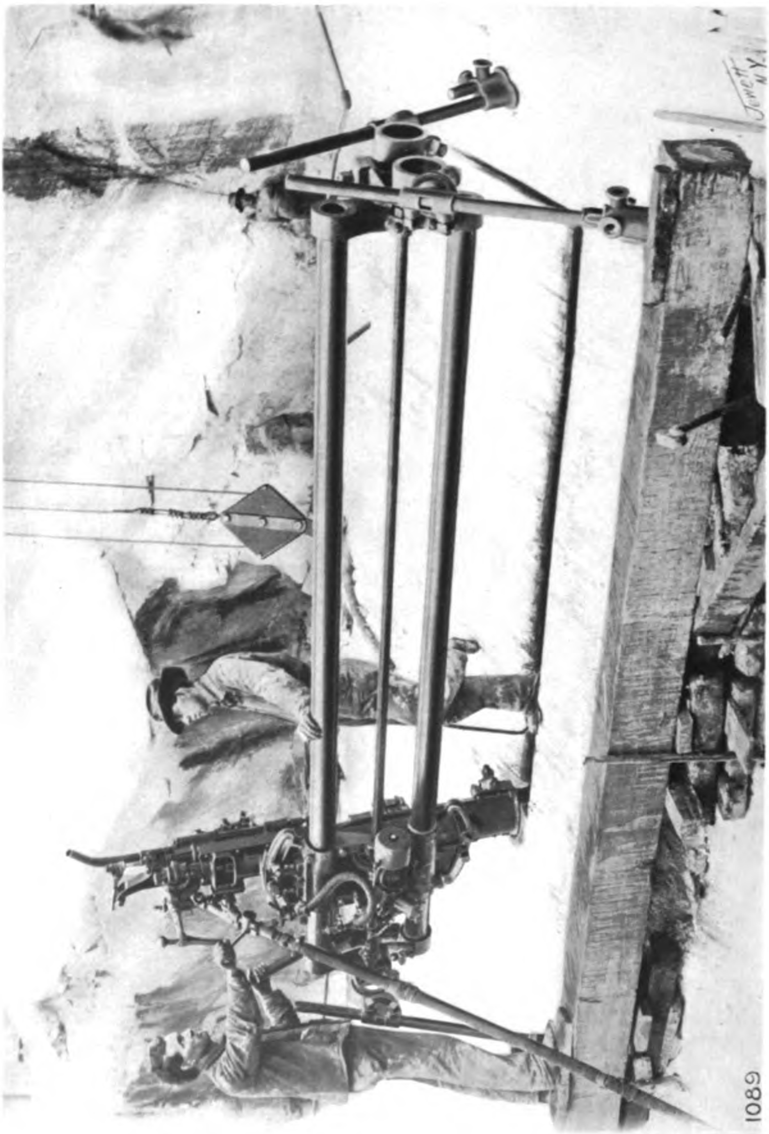
The "Broncho" Channeler at the Waverley Marble Quarries, Tuckahoe, N. Y.



The "Broncho" Channeler arranged for transferring.

The illustrations show that the "Broncho" consists of a carriage supporting the cutting engine, mounted on two parallel bars along which it is moved automatically by means of a three-cylinder engine actuating a traveling feed nut. The speed of this engine is limited by a governor, but within this limit can be regulated at will, giving the carriage a travel suited to varying qualities of material. The engine is automatically reversed at each end of the travel; or the stops can be set at any intermediate point, causing the carriage to move back and forth at less than full bar length and at any desired part of its travel.

While the cutting engine on the old bar channeler resembled a heavy rock drill in construction and operation, the channeling engine and valve gear on the "Broncho" are very similar to those used on the heavy track machines. The cylinder is three



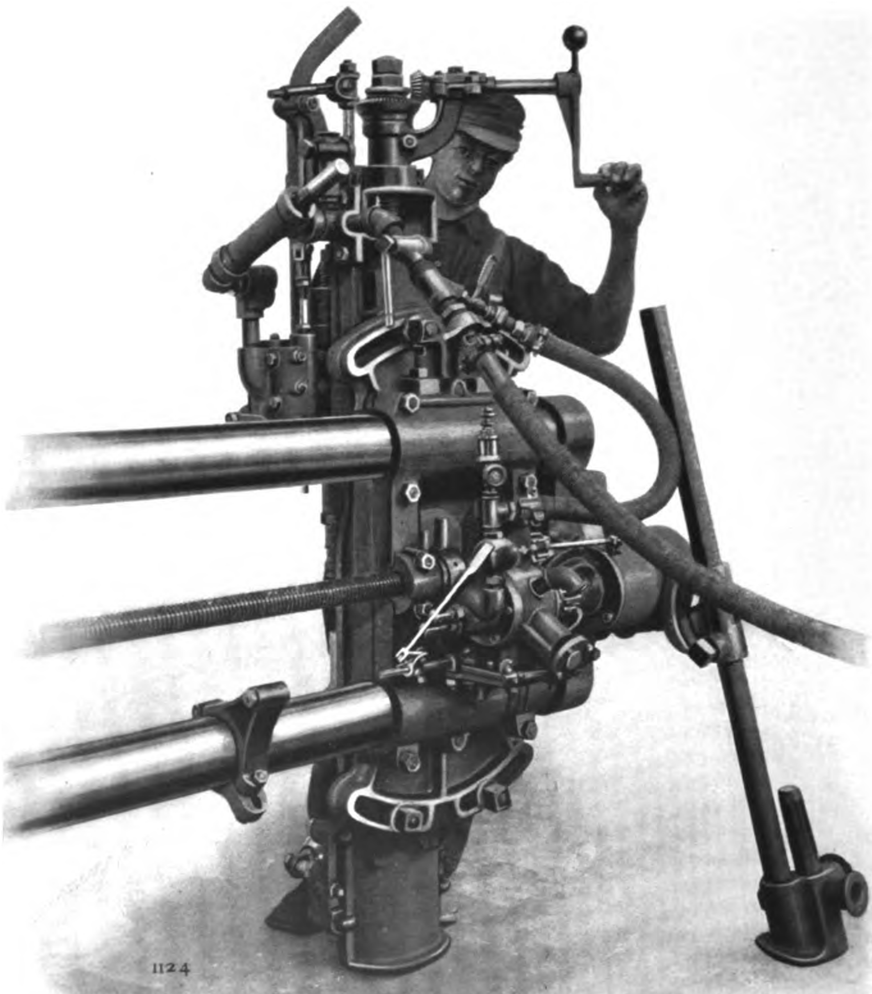
The "Broncho" Channeler on a Side Hill at the Waverley Marble Quarries, Tuckahoe, N. Y.

and one-half inches in diameter. The full stroke is six and one-half inches; it can be varied, however, from full normal down to two inches. A cushioning device puts the force of the blow under ready control. This latter arrangement is a most valuable feature in starting cuts, in working through soft spots, or in cutting across splits and seams. The valve action is moved by the piston tail rod passing through the back head, but is wholly independent of the length of stroke. This tail rod further secures all the advantages of a back piston guide, in relieving the action, reducing the wear on piston rings and cylinder bore, and in giving a free, easy motion with no tendency whatever to bind.

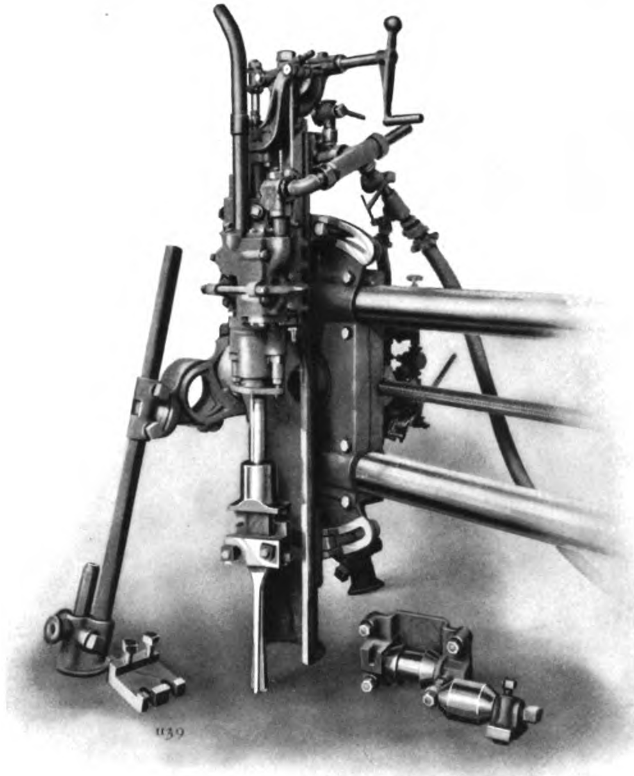
A simple attachment permits the "Broncho" to be used in drilling a round hole at either or both ends of its travel. This is the only machine which will cut an open channel, as well as drill a hole, in any position from vertical to horizontal. When used as a rock drill, the roller guide attachment is removed by loosening four hook bolts; the rotation is then thrown in gear; and a regular drill steel is applied in the usual manner.

A novel and most valuable feature of the "Broncho" Channeler is the Sergeant patent roller guide. It consists of two case-hardened steel rollers between which the steels work. Its use dispenses with the old-style cross-head, dowel pins, guides, etc. The cylinder is short, and the piston being freed from the weight, friction and pinching effect of the cross-head, the stroke of the machine is much more rapid and the blow harder. The rollers guide the steels on all four sides, preventing them from glancing off in the cut. The use of the roller guide leaves the machine free to run with even more speed and power than a rock drill of the same size. The guide arrangement is fastened to a plate and can be raised or lowered on the channeler shell. In changing steels, one bolt is loosened and the front roller simply swung aside. A long experience with this novel device has shown no appreciable wear.

The feed crank of the "Broncho" can be swung to the right or left hand side of the machine, or clamped in any position at the operator's convenience. The leg adjustments are universal and rigid, a cone clamp effect being secured which gives the utmost stiffness to the mounting. The lower ends of the legs are fitted with shoes and lugs for the application of a pinch bar in moving the machine. Pointers are also provided in the shoes which can be "spotted" into the rock whenever a tendency appears to jar out of line with the cut on an inclined surface.



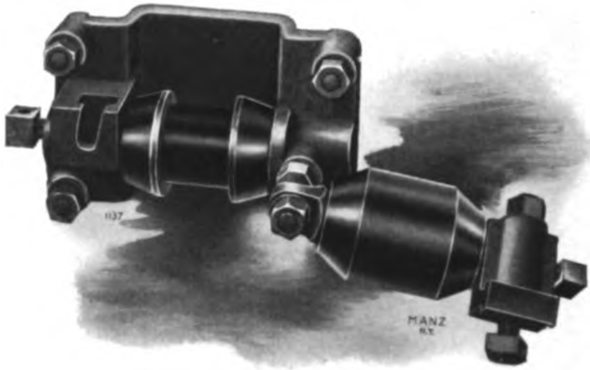
Rear View of the "Broncho" Channeler drilling the End Hole.



Front View of the "Broncho" Channeler drilling the End Hole; Roller Guide removed.

The normal full cut of the "Broncho" is ten feet six inches long and under favorable conditions a depth of twelve feet six inches has been reached. The machine will cut at any angle, this adjustment being secured by loosening one nut at each end of the frame and swinging the bars on center. A swinging adjustment in the plane of the cut is also provided, permitting the channeler to transfer cuts and work close up into corners.

The performance of the "Broncho" Channeler depends of course upon the hardness and quality of the material worked in, the steam or air pressure used, and the conditions under which the machine runs. Thoroughly tested in some of the hardest marbles, the "Broncho" has been found to cut practically the same amount as the heavier track machine. This surprising result is due to the fact that the full power of the larger machine would shatter the marble and cannot therefore be applied.



Roller Guide for the "Broncho" Channeler.

The light, rapid blow of the "Broncho," on the contrary, is fully effective and its full cutting capacity always available. In hard marble and limestone it will average 40 square feet of cut per day of ten hours, and in softer marble 80 to 120 square feet in the same time. Properly handled in ordinary sandstone, its performance is 75 to 125 square feet per day. It is especially effective in slate quarries, doing rapid, cheap work at the rate of 60 to 120 square feet per working day. In oölitic limestone, 125 to 200 square feet per day is an average rate.

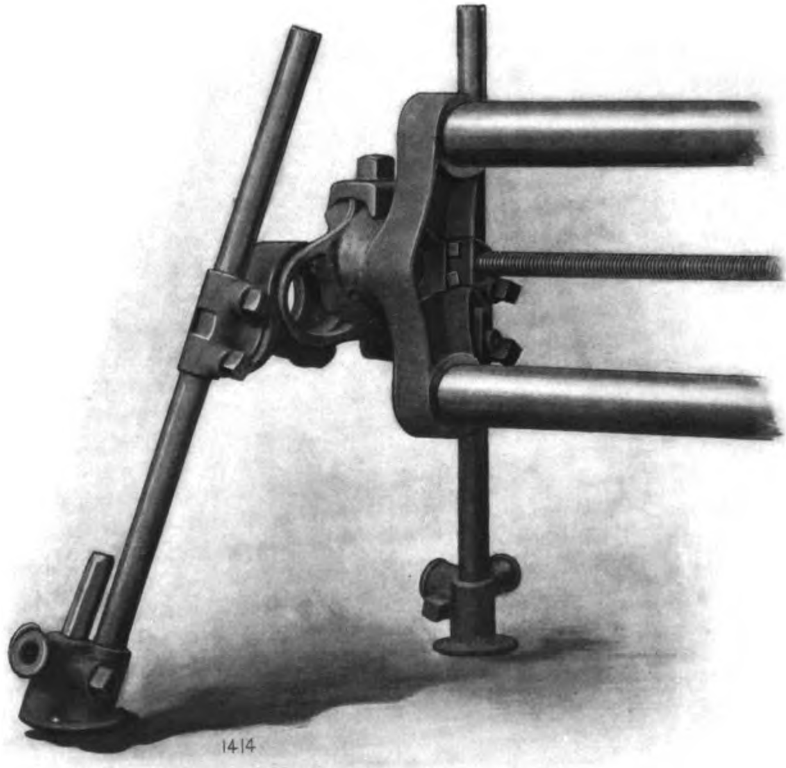
The "Broncho" does its best work in cuts seven to ten feet deep, with 100 pounds pressure at the throttle. But it runs well on lower pressures. The operating expenses are low, only one operator and a helper being required.

The equipment with each machine is as follows:

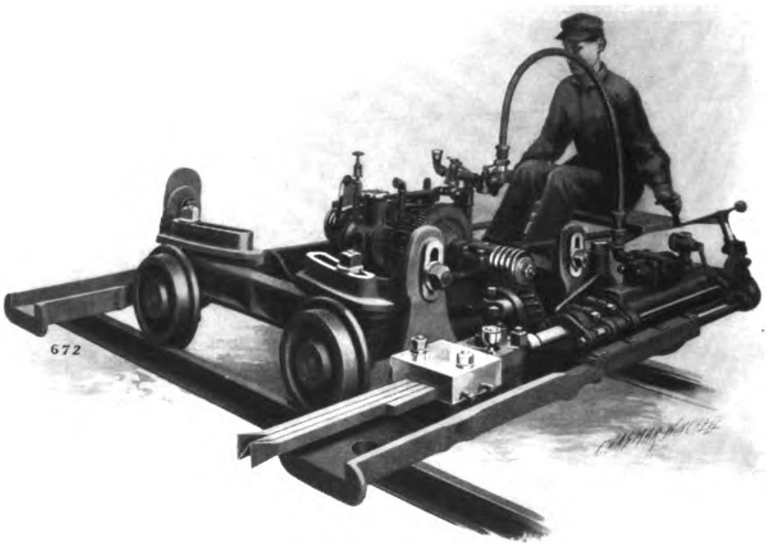
One tool chest, containing shims, clamps, hammer, level, square, three files, cold chisel, eleven wrenches, oiler, gauge for bitts, handle, clamp, set screws, waste, packing; cross-head clamp, bolts and nuts; one set of drill steels, one set of channeling steels; fifty feet of hose, one jack and lifting bales, iron bar and scoops, scrapers, and sand pump.

Specifications of the "Broncho" Channeler are as listed below:

Length over all, ...	14 ft.
Width over all, ...	2 ft., 6 ins.
Height from bottom of shell to top of tail rod, with piston at back head . . .	6 ft.
Free air required per minute.	175 cu. ft.
Boiler H. P. required, when run by steam,	20 to 25.
Net weight, with equipment	2,800 lbs.
Domestic shipping weight .	3,500 lbs.
Export shipping weight, . . .	3,700 lbs.



End Pieces and Leg Adjustments for "Broncho" Channeler.



The Ingersoll-Sergeant Undercutting Track Channeler

THE Undercutting Track Channeler was designed to meet conditions in quarries of marble, slate, sandstone and other rocks in which there are no free horizontal beds, and the rift or cleavage of the stone is vertical or nearly so. In such places it is necessary to cut under the bench as well as channel the sides.

The machine consists of a heavy, stiff frame of cast iron mounted on four chilled wheels carried on steel axles running in babbitted boxes. Upon this truck is mounted a standard Sergeant three-cylinder engine, geared through worms to both axles and automatically feeding the machine along its track. At either end of the frame is a special guide shell, provided with a swinging adjustment in both horizontal and vertical planes, by means of which all angular conditions may be met and cuts carried clear into the corners. The shells are hung

very low, thus giving the least possible offset in cutting. The use of the two shells permits the channeler to work close to the wall in either direction and the adjustments adapt the machine to deposits at any angle or dip.

The cutting engine has a cylinder 3½ inches in diameter, and is closely similar to the standard "F" size drill. It has the usual solid chuck and U-bolt, and the Sergeant release rotation. A special feed screw cross-head is furnished, with bevel gears on crank and screw whereby the former turns in a horizontal, instead of a vertical plane. This permits the channeler to work closer to the track and reduces the height of the bench left. For putting in end holes, or drilling a line of "lofting" holes, standard "F" drill steels are used, the feed being 18 inches. When channeling, the steels used are three 1 x 1 inch steels, held in a clamp on a special cross-head fitting into the chuck.

The truck engine is started, stopped, speeded and reversed by a single lever; and this lever, with feed crank, throttle, and lubricator, is within easy reach of the operator without changing his position.

Outfit and Equipment

The equipment of each Undercutting Channeler includes the following:

One truck complete, with three-cylinder engine, worm shaft, gear, and clamps and hinge pieces.

One right-hand shell bare, but with standards and necessary connecting pieces.

One left-hand shell complete with standards and connecting pieces, feed screw and bevel gear crank.

One "F" 3½-inch steam drill, 1¼-inch shank, with the "15" style front head and fitted with Sergeant rotation and pawl-releasing attachment.

Two right-hand cross-head clamps.

Two left-hand cross-head clamps.

Four clamp keys.

One operator's seat.

One set of "F" drill steels for end holes, to a length of 7 feet 6 inches over all, in runs of 18 inches.

One set (2 gangs, 3 steels to a gang), of 1 x 1 inch channeler steels, starting with 1 foot 6 inches, to a length of 7 feet 6 inches over all, in runs of 12 inches, suitable to channel to a depth of 7 feet.

Two 12-foot sections of track.

One 6-foot section of track.

One 50-foot length of 1-inch 5-ply marline-wound steam hose, with couplings.

Eight fishplates.

Sixteen fishplate bolts and nuts.

One set steel wrenches.

One drill throttle. One No. 8 lubricator. One piece packing. One exhaust pipe. One metallic hose for connecting engine. Two plug cocks and piping. One part sheet.

Specifications

The detailed specifications are as follows:

Length over all, 5 feet 10½ inches.

Width over all, 8 feet, 3 inches.

Gauge of track, 4 feet ⅜ inch, inside.

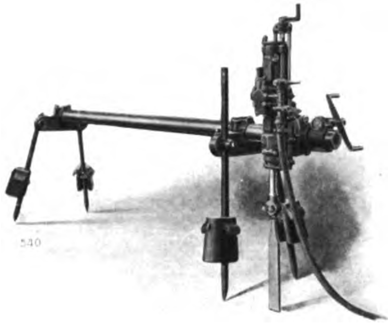
Height from top of rail to top of machine, 2 feet 10 inches.

Distance from bottom of rail to cut when undercutting horizontally, *i. e.*, height of bench left in cutting, 8½ inches.

Total weight for domestic shipment, 6,800 pounds.

Total weight for foreign shipment, 7,500 pounds.

Ingersoll-Sergeant Machines for the Quarry



Quarry Bar

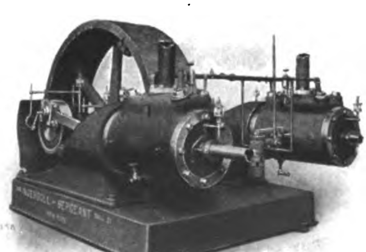
Rock Drill

"Little Jap" Hammer Drill

Gadder

Air Compressors

A Steam-Driven Duplex Compressor of the Corliss Type



A Small Duplex Power-Driven Machine

Ingersoll-Sergeant Publications

No. 5. Catalog—Labor Saving Tools Operated by Compressed Air.
No. 35. Catalog—Air Compressors.
No. 43. Catalog—Rock Drills, Mining and Quarrying Machinery.
No. 51. Catalog—Compressed Air vs. Electricity in Coal Mines.
No. 52. Catalog—Coal Mining Machinery.
No. 73. Catalog—Water Lifted by Compressed Air.
No. 81. Catalog—Flowing Oil Wells with Compressed Air.
No. 109. Pamphlet—Compressed Air in Railroad Shops.
No. 146. Booklet—The use of Compressed Air in the Monon Railroad Shops.
No. 147. Booklet—Pumping Water by Compressed Air at Dixon, Ill.
No. 148. Booklet—Model Compressed Air Foundry Plant.
No. 154. Booklet—Rock Drill.
No. 167. Booklet—Abundant Pure Water Underground. The Air Lift.
No. 193. Booklet—Baldwin Acetylene Lamp for Mines.
No. 242. Booklet—Moving 100,000 Tons of Rock. Rock Drills.
No. 254. Booklet—Rock Drill Estimate.
No. 322. Booklet—The "Broncho" Channeler.
No. 337. Pamphlet—Before and After. Quarrying.
No. 340. Booklet—Blue Book of Air Compressors.
No. 341. Booklet—Driving the New York Subway.
No. 346. Pamphlet—The Central Air Plant.
No. 353. Pamphlet—The "Radialaxe" Coal Cutter.
No. 355. Booklet—Compressed Air Displacement Pumps.
No. 540. Booklet—The City of Rockford. Rock Drills.

A series of bulletins relating particularly to "Labor Saving Tools Operated by Compressed Air" has been started. Those already issued are :

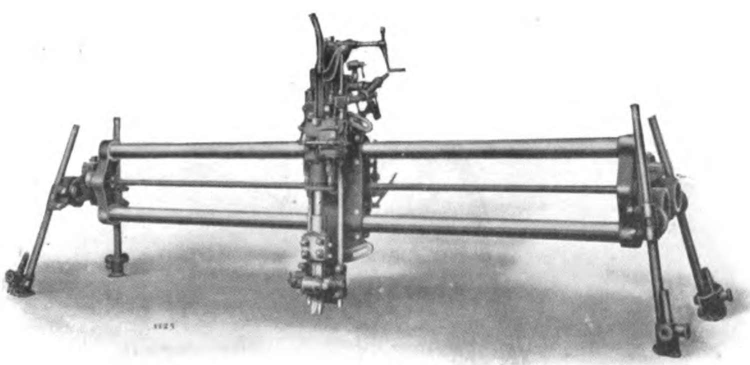
No. 2000. The MacDonald Rivet Forge.
No. 2001. The "Little Jap" Hammer Drill.
No. 2002. Track Laying on the Williamsburg Bridge.
No. 2003. The "Little Jap" Hammer Drill (Second Edition).
No. 2004. Stone Working Tools.

Send us your name and address and we will send the others as they are issued.

Rogers & Company Chicago New York

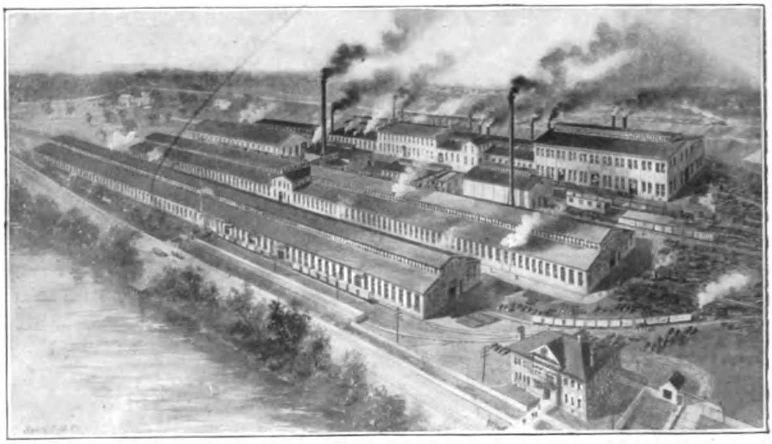
Form 322

THE "BRONCHO" CHANNELER

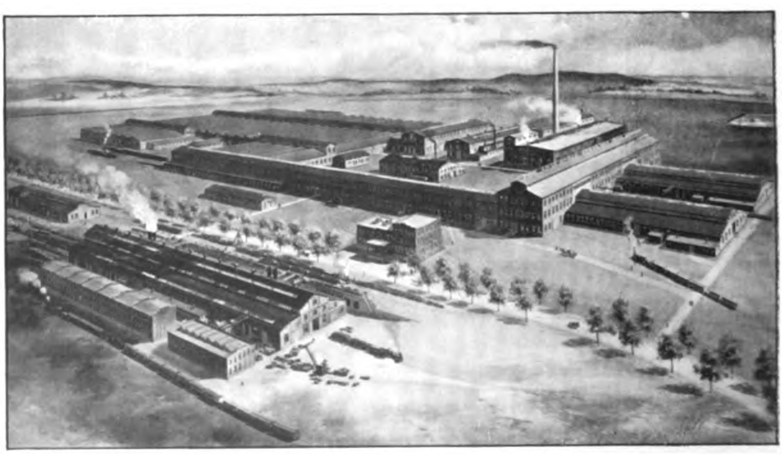


THE INGERSOLL-SERGEANT DRILL CO.

26 Cortlandt Street
NEW YORK



Manufacturing Plant of the Ingersoll-Sergeant Drill Co. at Easton, Pa.



Manufacturing Plant of the Ingersoll-Sergeant Drill Co. at Phillipsburg, N. J.

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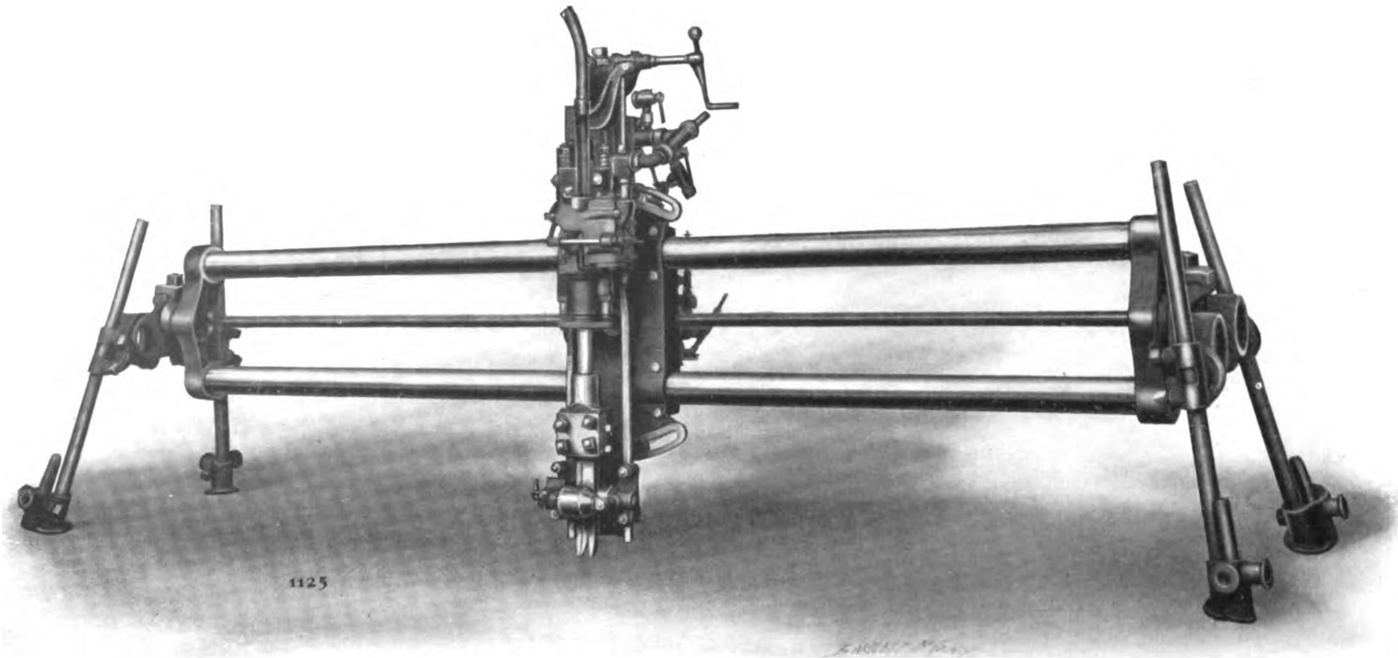


The "Broncho" Channeler.

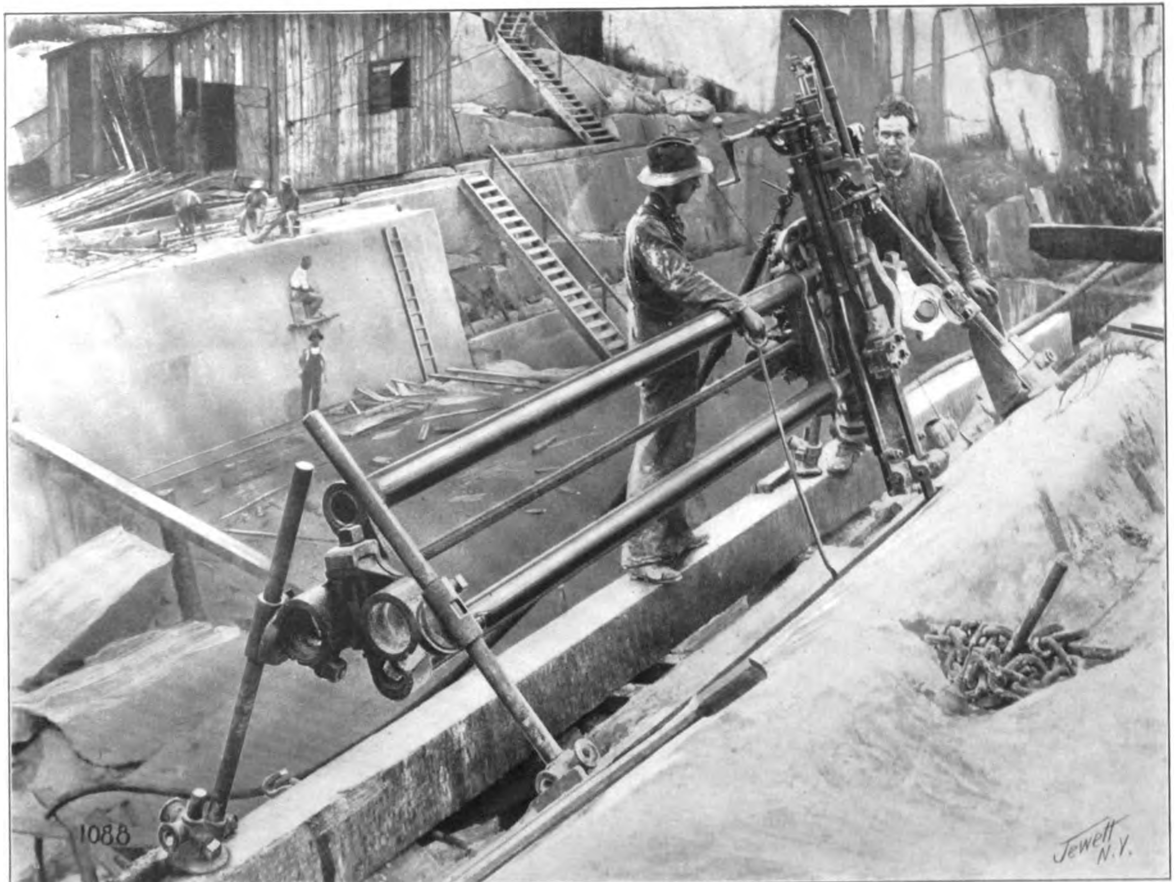
THE "BRONCHO" CHANNELER

AN important development, following the introduction of the track type of channeler is the "Broncho" Channeler, a very efficient and light model machine, which is suited for a wide range of work in quarry, contract, and other service. The large Track Channeler is of greatest value in heavy work, designed to do fast, cheap cutting; handle long and deep cuts, and work in the most difficult materials; but there are also many places where the lighter and cheaper "Broncho" type will be found more economical and satisfactory in operation. As channeling frequently has to be done on material which dips or inclines sharply, the "Broncho" is made very flexible in its adjustment, and is readily adapted to difficult places where it would be impracticable to set the heavier track type of machine. It is also well suited for light work in quarries, in developing new quarries where the value of the material may be proved up before heavy investments in permanent machinery are made, and it is always useful in cutting sumps, key blocks, enlarging the walls of quarries or excavations, and can be used in confined and uneven places.

While this machine is an outgrowth from the Bar Channeler, it should not be confused with the earlier types, as it is the result of a wide experience, changes in design having greatly increased its power, capacity and adaptability.

As shown by the illustrations, this machine consists of a carriage mounted on two parallel bars, along which it is moved automatically by a three-cylinder engine actuating a traveling feed nut. This engine is controlled by a governor, and the speed of travel can be regulated to suit the varying character of material, allowing the strokes to chip closely one after another or to travel rapidly back and forth where preferred. The engine will reverse automatically at each end of the cut or the stop can be moved, causing it to travel back and forth at less than the full bar length and to any desired point.

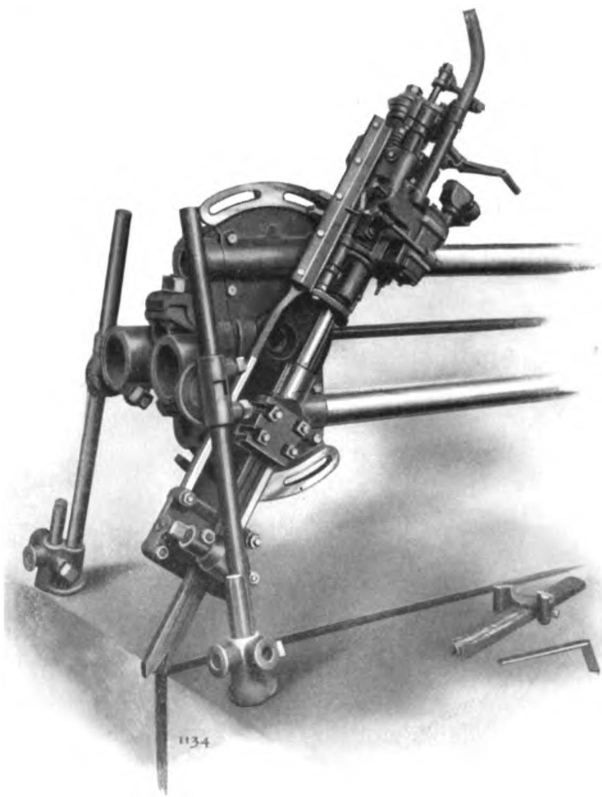
The cylinder is 3½ inches in diameter with a 6-inch stroke, and the stroke will vary from 2 to 6 inches, when desired. There is a cushioning device whereby the force of the blow can be controlled. This is a valuable feature in starting cuts, in working through soft spots or across splits and seams.



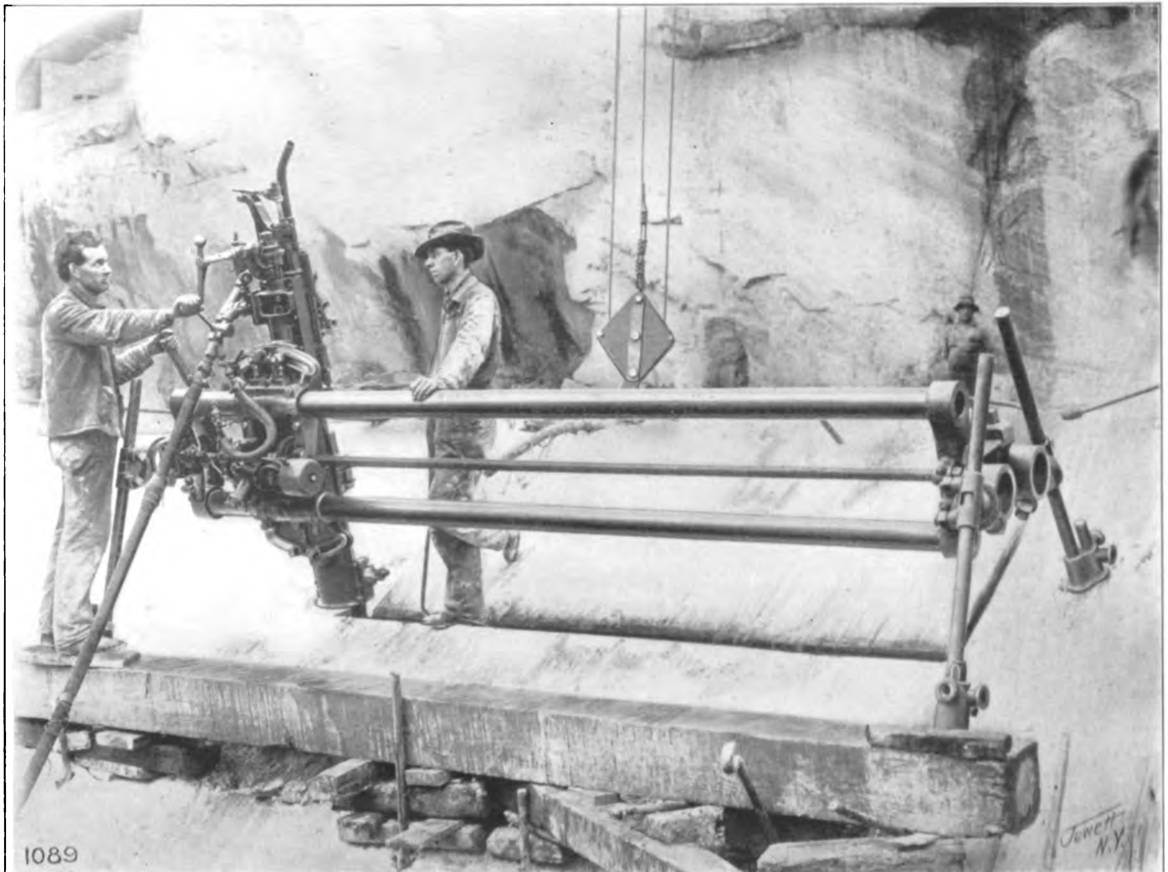
The "Broncho" Channeler at the Waverley Marble Quarries, Tuckahoe, N. Y.

The channeling engine on the old bar channeler resembles a heavy rock drill in construction and valve motion, while this channeling engine and valve gear is similar to that used on the standard heavy track channeler. The cylinder, being short and light, and the piston being freed from the weight, sliding friction and pinching effect of the cross head, the stroke is much quicker and harder. While the machine runs best on dry high pressure steam or air, yet it runs well under conditions of low pressure and wet steam where the older model would give but indifferent service.

The valve motion is worked by a tail rod passing through the top head, serving also as a guide for the piston. Wear on the piston rings and cylinder is consequently very light and the motion free and without binding.



The "Broncho" Channeler Arranged for Transferring.



The "Broncho" Channeler on a Side Hill at the Waverley Marble Quarries, Tuckahoe, N. Y.

A simple device has been introduced enabling this machine to be used for drilling a round hole at one or both ends of the cut. This is now the only machine that will cut an open channel and also drill a round hole in any position from vertical to horizontal. When used as a rock drill, the roller guide arrangement, shown in cut No. 1137, is readily removed by loosening four hook bolts; the rotation device is thrown into gear, and a regular drill steel used in the ordinary manner.

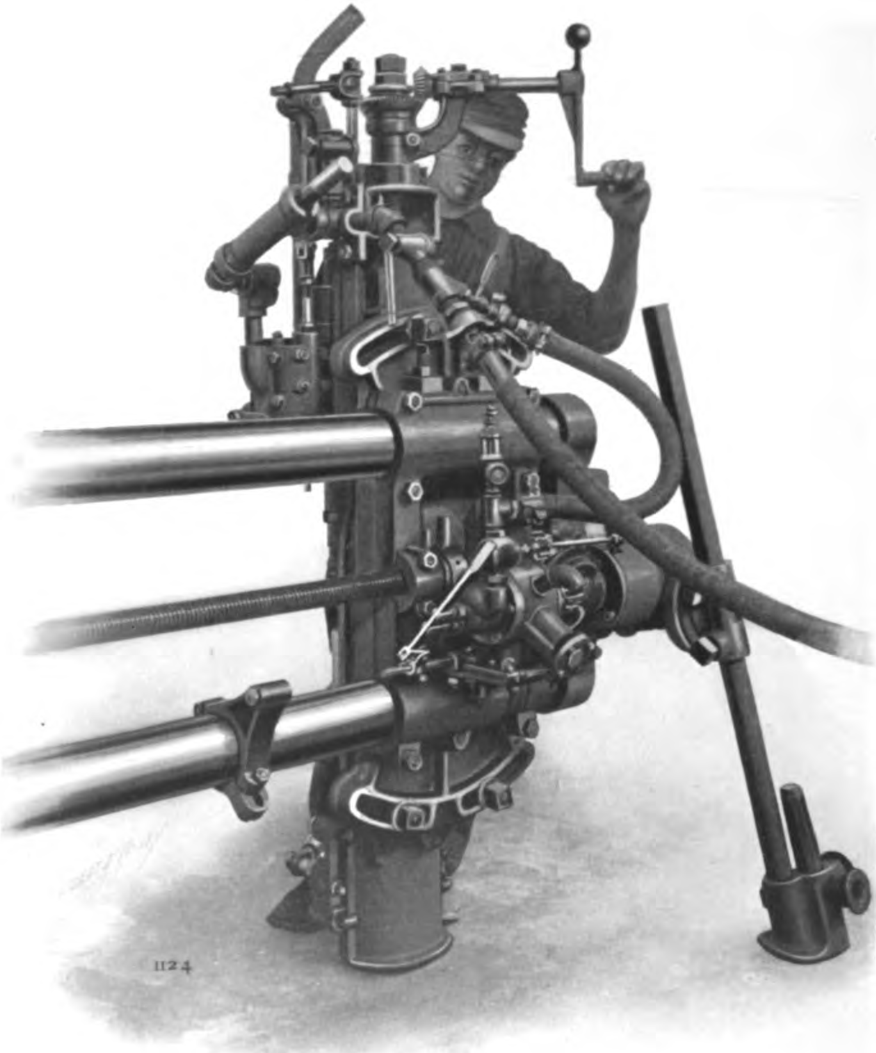
A most important feature of this machine is our patent roller guide. This consists of two case-hardened steel rollers between which the steels work. A considerable experience with it shows no appreciable wear. This enables us to dispense with the older style cross-head, dowel pin, guides, etc. While the new machine will finish cuts about two feet longer than the old bar channeler, it is still much lighter, more rigid and practicable. The roller also prevents the steel from glancing sideways, as it is guided on all four sides.

In changing bits, one bolt is loosened and the front roller swung aside. The guide arrangement is fastened to a plate which can be raised or lowered on the shell of the machine. This roller guide is a very important improvement, as it leaves the machine free to run practically without friction with even more speed and force than a rock drill of the same size, increasing its power and capacity for putting in deep channels or for work under adverse conditions generally.

The feed crank can be swung to either right or left hand side of the machine, to suit the convenience of the operator, and clamped in any position.

The leg adjustment at each end of the bar is universal and rigid, being held by cone clamp effect, which greatly stiffens the machine in operation. The lower ends are fitted with shoes, having lugs for quick movement of the machine with a pinch bar about the floor of the quarry. A cut finished, the machine may be set for a second cut in a few minutes. These shoes are provided with a pointer, which can be "spotted" into the rock and held by set screws, where the machine, on account of the inclination of the rock, shows any tendency to jar out of line with the cut.

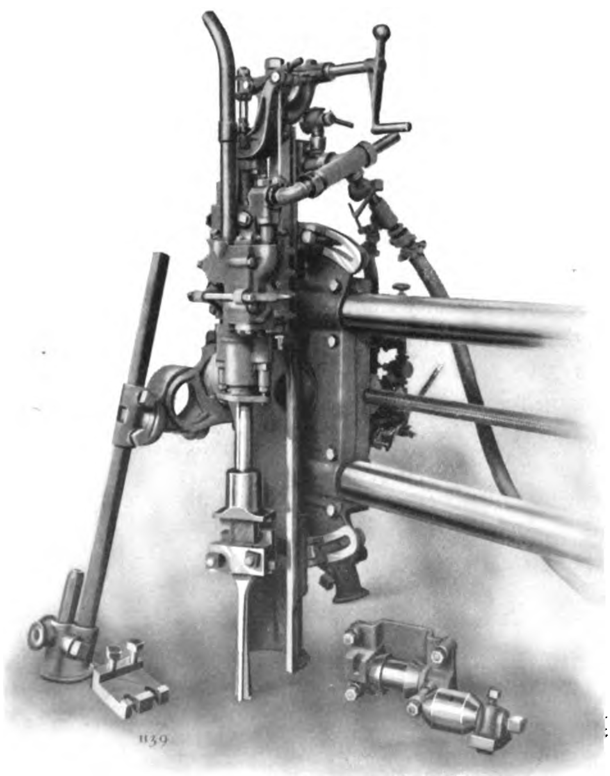
The machine will cut at any angle, and may be adjusted by loosening a nut on each end piece and swinging the bar on centres. It will also transfer cuts to each end of the bar, this position being shown in cuts Nos. 1134 and 1138.



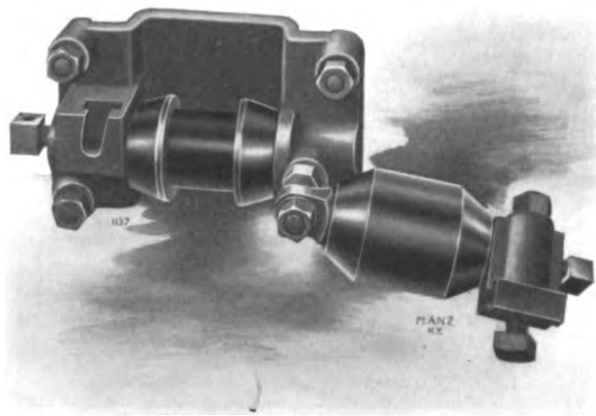
Rear View of the "Broncho" Channeler Drilling the End Hole.

It is designed to make a cut 10 feet 6 inches long, and under favorable conditions has cut as deep as 12 feet 6 inches.

The hardness of the rock and the conditions of channeling vary so much that it is difficult to give an accurate idea of what it will do under all conditions, but in hard marble or limestone it will cut on an average of 40 square feet per day of 10 hours, and in softer marble up to 80 or 120 feet. It has been thoroughly tested in some of the hardest marbles, cutting practically as much as the track machine, because it runs very fast and does not strike so hard a blow as to stun the material. In some marbles the full power of the track machine can't be used, which accounts for this comparatively light and simple machine having nearly the same capacity. Properly handled, it is capable of cutting 75 to 125 square feet



Front View of the "Broncho" Channeler Drilling the End Hole; Roller Guide Removed.



Roller Guide for the "Broncho" Channeler.

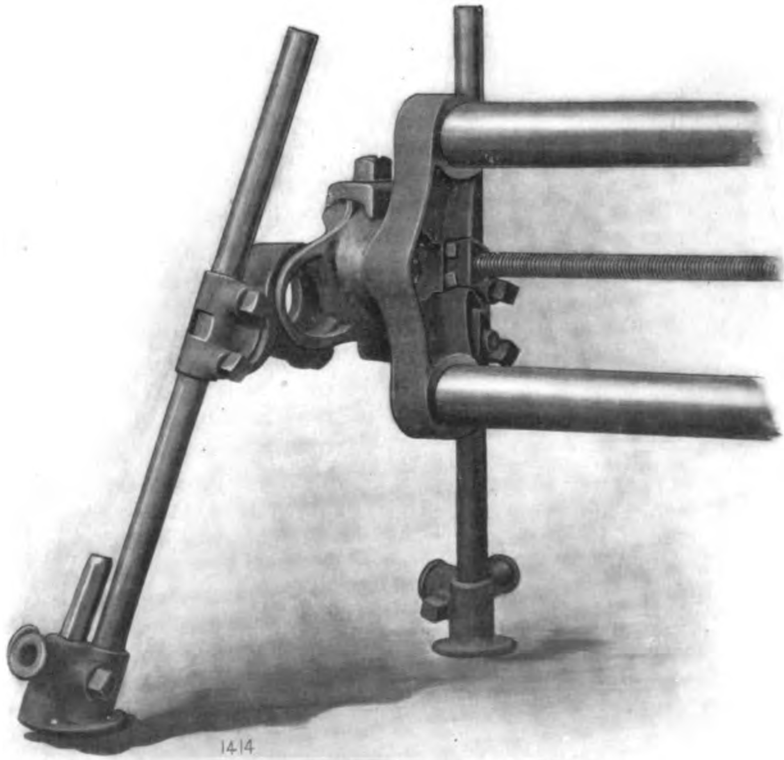
in ordinary sandstone. It is especially adapted for fast, cheap work in slate, cutting 60 to 120 square feet, and will cut 125 to 200 square feet in oolitic limestone. Its capacity depends, of course, entirely on the material and the steam or air pressure delivered to the machine. Its best work is done with cuts 7 to 10 feet deep and with 100 pounds pressure at the channeler, although it will run well with lower pressures. It requires about 175 cubic feet of free air per minute, and a 20 to 25 horse power free steaming boiler is recommended.

The operating expenses are very low, only one runner and helper being necessary.

The equipment consists of the following:

One tool chest, containing shims, clamps, hammer, level, square, 3 files, cold chisel, 11 wrenches, oiler, gauge for bits, handle, clamp, set screws, waste, packing, crosshead clamp, bolts and nuts, 1 set of drill steels, 1 set of channeling steels, 50 feet of hose, 1 jack and lifting bales, iron bar and scoops, scrapers, sand pump.

The net weight of the "Broncho" Channeler and equipment is 2,800 pounds; the domestic shipping weight, 3,500 pounds; export shipping weight, 3,700 pounds.



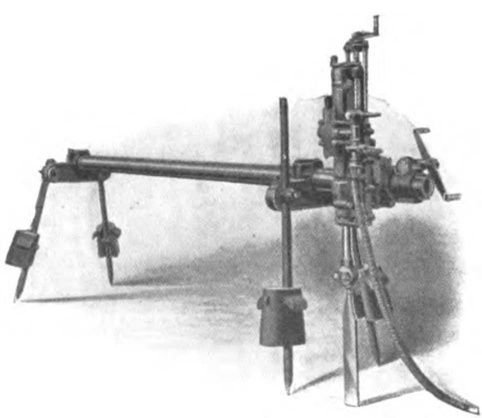
End Pieces and Leg Adjustments for "Broncho" Channeler.

QUARRYING MACHINERY

TRACK CHANNELER.

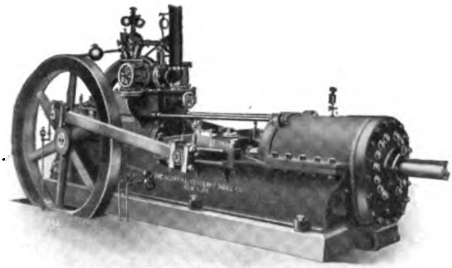
WHILE the "Broncho" Channeler is particularly adapted to meet certain conditions already mentioned, there are a number of other machines, manufactured by THE INGERSOLL-SERGEANT DRILL CO., which are invaluable to quarrymen. Among them are the Rock Drill, the Track Channeler, the Undercutting Channeler, the Gadder, and the Quarry Bar. These are described and illustrated in our Rock Drill Catalog No. 43, which will be sent on request.

ROCK DRILL.



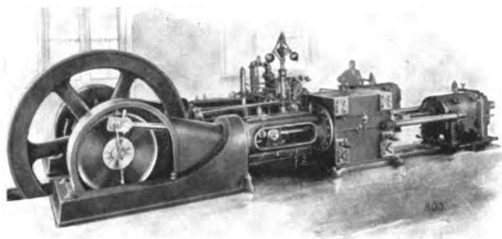
QUARRY BAR.

AIR COMPRESSORS

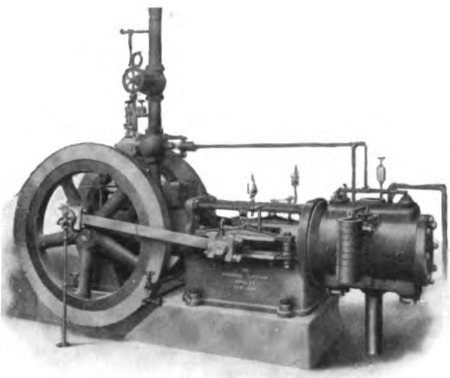


THE INGERSOLL-SERGEANT DRILL Co. manufactures a complete line of Air Copressors, meeting all conditions required for quarry work. Machines of all types and duties, operated by steam, belt or electric motor, are shown in the Compressor Catalog, which will be mailed on request.

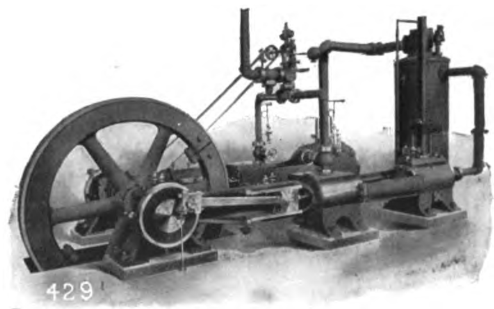
CLASS "A" COMPRESSOR.



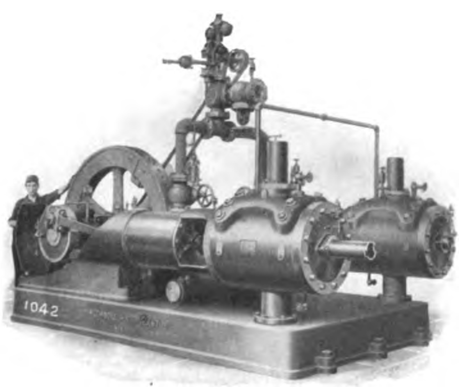
CORLISS COMPRESSOR.



CLASS "F" COMPRESSOR.



CLASS "G" COMPRESSOR.



CLASS "H" COMPRESSOR.

CLASS "J" COMPRESSOR.

MAIL AND EXPRESS JOB PRINT
9-15 MURRAY ST., N. Y.

THE GIBSON-INGERSOLL

"Electric-Air" Track Channeler

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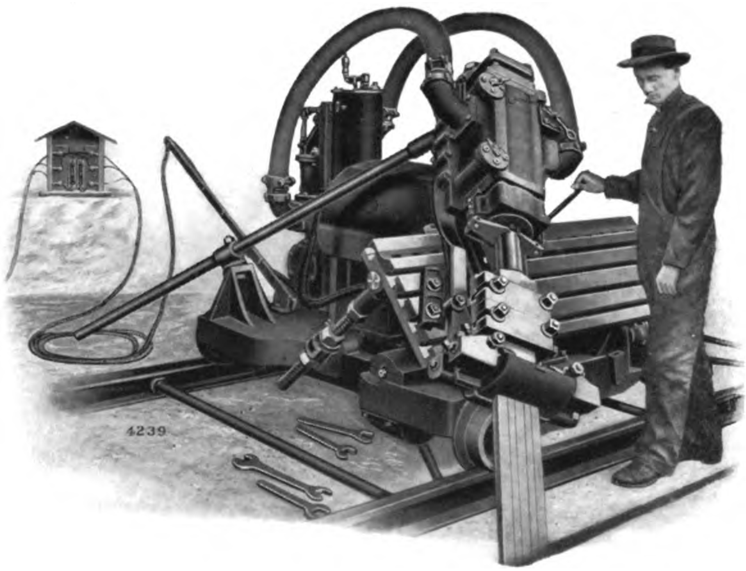
INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

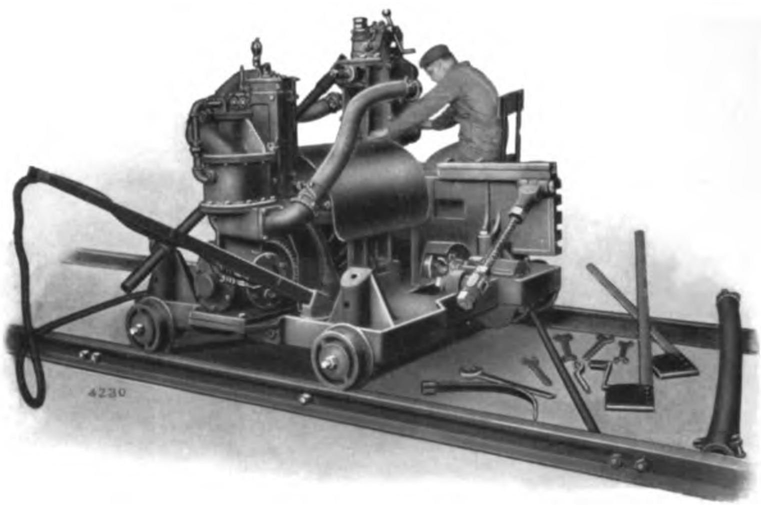
Form No. 6102 April, 1910



Front view of the "Electric-Air" Channeler, showing it adjusted for making a transfer cut

ELECTRIC power has become a common feature of mining and industrial operation, in which it has gained a firm foothold on grounds of convenience, economy and adaptability. But the quarry field has only recently yielded to the current tendency toward electrical operation.

The reason for this has been that the highly specialized process of stone quarrying has offered difficulties to be overcome only by the use of steam or compressed air in percussive machines. Until



A rear view of the "Electric-Air" Channeler, showing the pulsator

a recent date the drilling and channeling of stone has never been successfully accomplished by means of electric power.

With the advent of the successful "Electric-Air" Rock Drill and the "Electric-Air" Track Channeler, however, these difficulties have been overcome; and the modern stone quarry may be electrically equipped throughout, meaning a great advance in the economy and convenience of quarry operations.

The "Electric-Air" Drill, the only practical and successful machine ever offered for drilling rock by electric power, is one of the standard Ingersoll-Rand products and is described in Bulletin No. 4109. More than 700 of these machines in operation for all purposes all over the world attest the complete success of this device.

The "Electric-Air" Channeler

The present Bulletin is devoted to the "Electric-Air" Track Channeler, which brings to the quarrying of dimension stone the flexibility and economy of electric transmission and the efficiency of the electric generator and motor, in combination with the sturdy reliability, large capacity and "stand-up" qualities of the compressed air or steam channeler.

This distinctly new machine has demonstrated its entire success in many instances. Notable among these are: the Vermont Marble Co., the largest marble producing concern in the world, which uses seven "Electric-Air" Channelers and thirteen "Electric-Air" Drills; the Dover White Marble Co., South Dover, New York, which uses five "Electric-Air" Channelers and three "Electric-Air" Drills; the Colorado Yule Marble Co. with three "Electric-Air" Channelers; and the Crystal River Marble Co. in Colorado.

The "Electric-Air" Principle

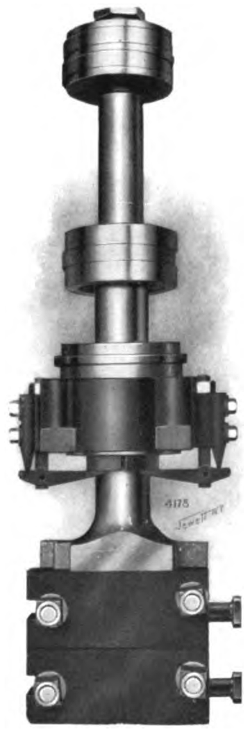
At this point let it be clearly understood that the "Electric-Air" Channeler is more than an air channeler with a portable electric driven air compressor. The device represents a complete system in which pulsations of compressed air, produced by a tandem single-acting pulsator driven by a standard electric motor, are applied to the piston of the cutting engine. There is nothing electrical about it, except the motor prime mover. The air is never exhausted or discharged to atmosphere, but is simply pulsated back and forth under pressure in a closed circuit. For every revolution or double stroke of the pulsator there is a blow and return of the channeler piston with its steels. Thus the speed of the cutting engine conforms exactly with the speed of the pulsator, and the simple speed controller on the motor affords the necessary speed variation in the cutting engine. There is no rigid connection between the motor pulsator and the cutting engine. Two short lengths of hose connect these parts and act as ports within which the air plays back and forth.

Channeler Essentials

Any new device, to gain acceptance in a productive industry, must either increase the output or reduce the cost of operations. Analyzed on this basis the four requirements of any successful stone channeler are found to be: economy in the use of power; low cost of up-keep or maintenance; ready adjustability to all classes of rock and to all working conditions; and large cutting capacity. It remains to be shown how the "Electric-Air" Channeler meets these requirements.

Power Economy

The ordinary air or steam-driven channeler takes at each stroke a full cylinder of air or steam, and exhausts or discharges it to atmosphere at practically full pressure. No advantage is taken of the expansive properties of the air or steam, the power of which is wasted.


The piston, lower head and chuck of the "Electric-Air" Channeler

The "Electric-Air" Channeler operates by air under a low pressure which is simply a transmitting agent between the piston of the pulsator and the piston of the cutting engine. The object of slightly compressing the air is to give it a greater density for the transmission of the pulsations imparted to it by the pulsator. In fact, the air is simply an unwearing, unbreakable cushion or spring between the pulsator and chopper; the pressure in the air is equivalent to a higher tension in the spring. Practically the only loss of power is that due to friction; and this is much lower than in the ordinary channeler, owing to the superior lubrication system and to the absence of any valve movement. As a matter of fact the actual requirements in three comparative cases are as given below.

Air Driven Channeler

325 to 450 cubic feet of free air per minute at 100 lbs., corresponding to 55 to 75 compressor I.H.P.

Steam Driven Channeler

27 to 35 Boiler H.P.

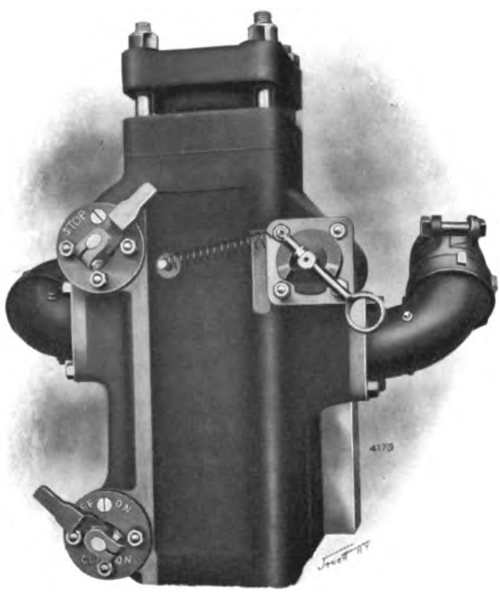
"Electric-Air" Channeler

10 to 12 Motor H.P., corresponding to about 18 steam I.H.P. at the generating plant.

That these are not theoretical figures is evidenced by the fact that the "Electric-Air" Channelers used by the Colorado Yule Marble Co. are regularly cutting channels to an average depth of 9 ft. with a power consumption of only 8 K.W. or 10 2/3 H.P.

Low Cost of Maintenance

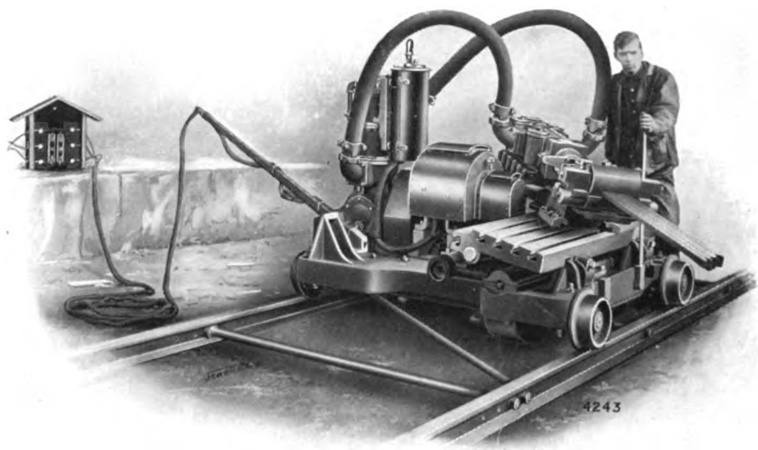
The extreme simplicity of the "Electric-Air" Channeler results in an endurance bringing the repair or maintenance cost below all former figures in channeler practice. There is only one moving part, the piston, as shown in the illustration herewith. There are no valves, no valve chest, no valve gear to get out of order and lose adjustment.



The cylinder and upper head of the "Electric-Air" Channeler, showing the cushioning valves

The pulsator is of the simplest type; one reciprocating piston with one connecting rod, and with no inlet or discharge valves, no jackets, no complication whatever. The moving parts of the pulsator run in an oil bath. The motor is of a standard type designed for the hardest service, with an ample overload capacity. It is geared to the pulsator and also through a friction clutch to a reversible traction gear, causing the travel of the channeler along its track.

The motor and connecting gears are protected by the sheet steel cover. The controller is of an enclosed dust-proof type. The vertical feed of the cutting engine is regulated by hand. The patented Sergeant roller guide replacing the heavy crosshead and



Illustrating the wide range of adjustability in the swing back and swivel head of the "Electric-Air" Channeler

guides has eliminated practically all of the friction formerly so excessive at this point.

No channeler is so simple in construction, has so few parts to wear out and so little mechanism to need attention, or is so easily operated as the "Electric-Air" Channeler.

Adjustability

Perfect control of the quality of the blow delivered, and ready adjustment to varying conditions, are provided, by means of the adjustable air pressure and the cushioning valves, shown in the illustration of the cylinder on page 5. The number of blows per minute can be regulated within a wide range by means of the motor controller. The swing back has a range of adjustment from vertical to horizontal. The swivel head has a swing up to 45° either side of vertical. The roller guide gives a peculiarly free-running, rapid-cutting machine and a tremendously effective blow. The perfect adjustability of the "Electric-Air" Channeler is of special value in marble quarrying, where the character of the blow must be adjusted exactly to the nature of the marble cut, so that the latter may not be injured. Control of feed and track travel are all conveniently located to the operator's hand without it being necessary for him to change his position.

Other Advantages

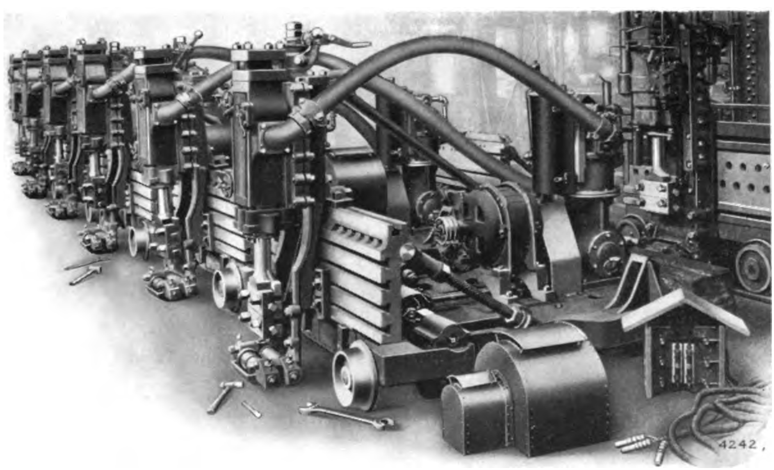
The large reduction in power required by the "Electric-Air" Channeler makes possible a much smaller power plant, including boilers, engines and generators. This means a smaller investment and a lower interest charge as well as a reduced fuel consumption.

The use of the "Electric-Air" Channeler substitutes electric wiring in the place of piping, thus avoiding the difficulties of condensed moisture, freezing up or bursting of pipe lines in cold weather, and delays while the pipes are being thawed out. It is much easier to change transmission lines than to alter pipe-line layouts. The absence of coal and ashes from the quarry results in a superior quality of stone free from surface discoloration.

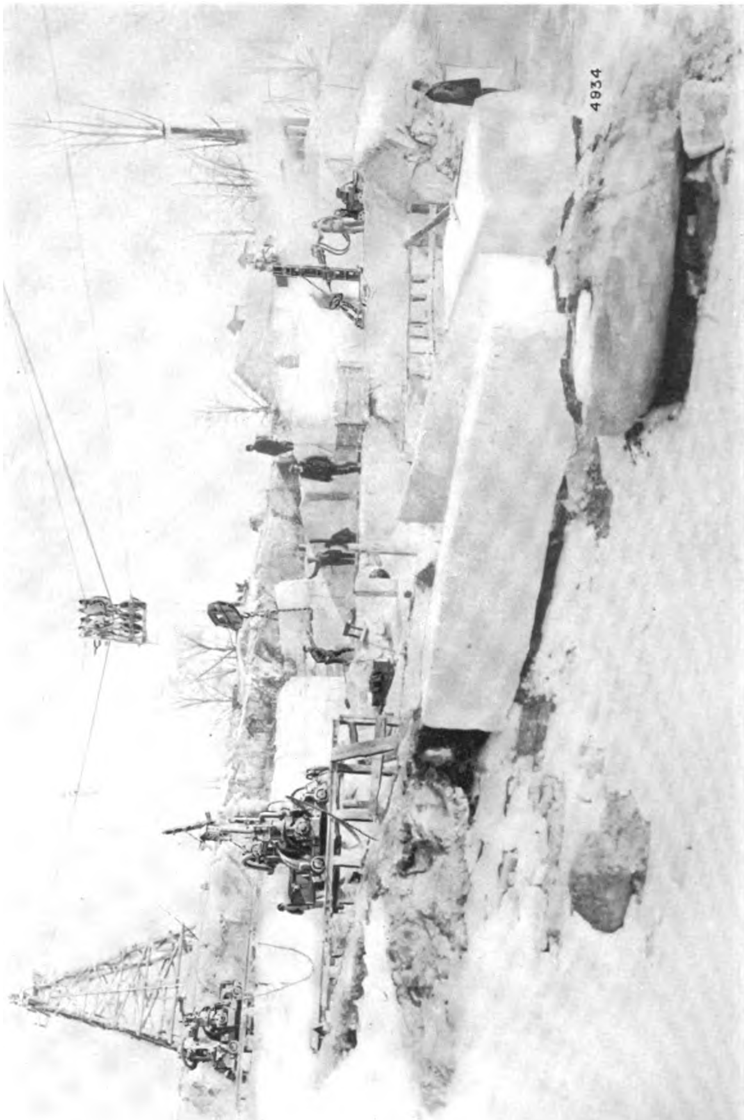
The electric power may be used for hoists and other purposes around the quarry plant. This new channeler, together with the "Electric-Air" Drill, makes it possible to put a quarry on an "electric" basis throughout without sacrificing any of the advantages peculiar to the use of compressed air for rock drilling and channeling.

Character of Current

The Company considers as standard, and recommends for all new installations, either 220 volt direct current, or 220 volt 3-phase, 50 or 60 cycle alternating current. The adoption of these stand-



A single order for "Electric-Air" Channelers; six complete outfits



"Electric-Air" Channelers and "Electric-Air" Drills on Gadder Frames in the Quarry of the Dover White Marble Co., South Dover, N. Y.

ards is the result of observations on several hundred "Electric-Air" Drills and on a number of "Electric-Air" Channelers operating under a wide variety of conditions. The "Electric-Air" Channeler, however, will be furnished to conform with any existing electrical conditions, as to voltage and character of current, whether direct or alternating. But a voltage of 220 is a safe, practical and reliable pressure for "Electric-Air" Channeler and Drill operation and it is sufficiently high for economical electrical transmission. The motors for this pressure are sturdy, dependable machines, and standard repair parts are always to be had at short notice. "Electric-Air" Channelers and Drills seldom work under ideal conditions for electric motors; moisture and dirt must usually be anticipated. A voltage of 220 reduces troubles in such cases to a minimum, while above this limit it is safe to say that difficulties will increase rapidly.

Guarantees

The "Electric-Air" Channeler is built in only one size, full specifications of which will be found tabulated on page 11. The machine is put out under the following guarantee:

THE "ELECTRIC-AIR" CHANNELER IS GUARANTEED TO BE EQUAL IN CUTTING CAPACITY TO ANY STEAM OR AIR DRIVEN CHANNELER OF STANDARD SIZE, OPERATING AT 100 POUNDS PRESSURE, AND IN DOING THIS WORK IT WILL USE NOT MORE THAN ONE-HALF THE POWER REQUIRED BY THE EQUIVALENT STEAM OR AIR DRIVEN CHANNELER.

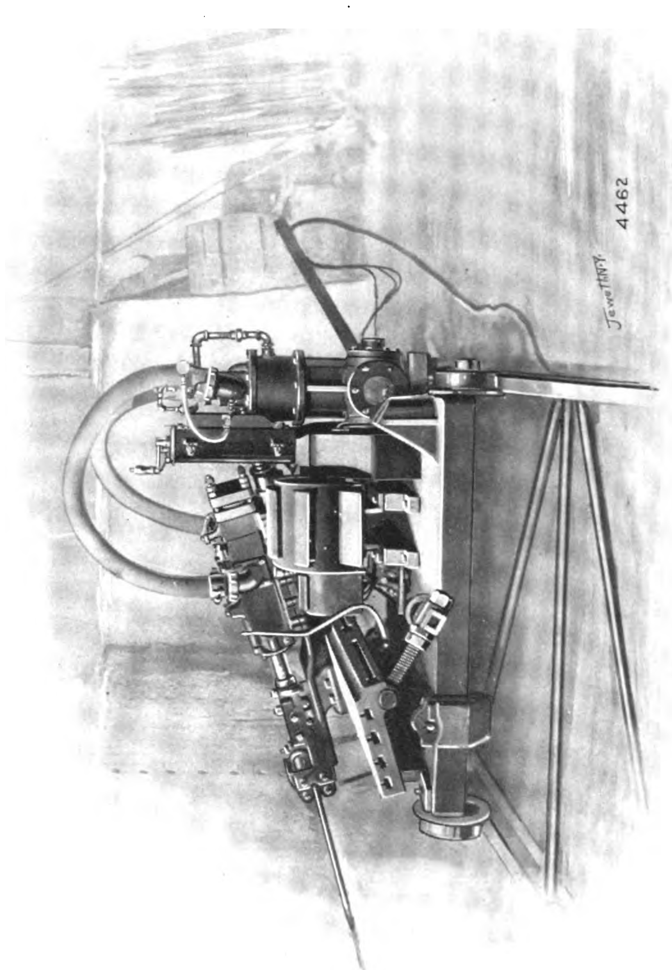
Equipment

One complete "Electric-Air" Channeler outfit includes the following:

One "Electric-Air" Swing Back, Swivel Head Track Channeler mounted on a rigid cast iron truck with single flanged truck wheels.

One pulsator rigidly mounted on the truck; one motor, either 220 volt direct, or 220 volt, 3-phase, 50 or 60 cycle, alternating current; and one speed-changing controller.

In addition to the above the following accessories are provided: 30 feet of flexible protected drag cable with connections; one drag pole; three 12-foot sections of track and one 6-foot section; one set of lifting bales; one spare chuck clamp; one main fuse box; a full set of wrenches; a full set of tools; and selected extra parts covering both the mechanical and electrical parts of the equipment. Channeler steels are furnished only on order, at extra cost.



"Electric-Air" Channeler at Work 185 Feet Below the Surface in a Quarry of the Vermont Marble Co.
Making an Undercut to Remove a Block

SPECIFICATIONS FOR THE

"ELECTRIC-AIR" TRACK CHANNELER

Diameter of Cylinder	7 inches
Length of Stroke	7 inches
Length of Feed	12 to 15 inches
Angular Range of Swing Back	Vertical to Horizontal
Angular Range of Swivel Head	45 deg. either way
Inside Gage of Track	5 feet 10¾ inches
Minimum Distance of Cut from Vertical Wall	7¼ inches
Distance from Center to Center of Cuts with Channeler Reversed on Track	7 feet 5 inches
Distance from Extreme Outer Edge of Rail to Center Line of Cut	5½ inches
Length Over All	5 feet 3 inches
Width Over All	8 feet
Height Over All from Top of Rail	6 feet 3½ inches
Weight of Channeler with D. C. or A. C. Motor, Pulsator and Speed Controller	8,200 lbs.
Total Shipping Weight of Channeler complete with D. C. or A. C. Motor, Accessories and Track Equipment, but no Steels	13,250 lbs.
Size of Motor supplied for Alternating Current	12 H. P.
Size of Motor supplied for Direct Current	15 H. P.
Power Required to Cut 7 feet deep	10 H. P.
Number of Running Points on A. C. Controller	8 forward, 8 reverse
Number of Running Points on D. C. Controller	5 forward
Type of A. C. Controller	Reversing Drum
Type of D. C. Controller	Non-Reversing Drum

Another View of the Dover White Marble Co.'s Quarry, Showing "Electric-Air" Channeler and Drills at Work

"NEW INGERSOLL" COAL PUNCHERS

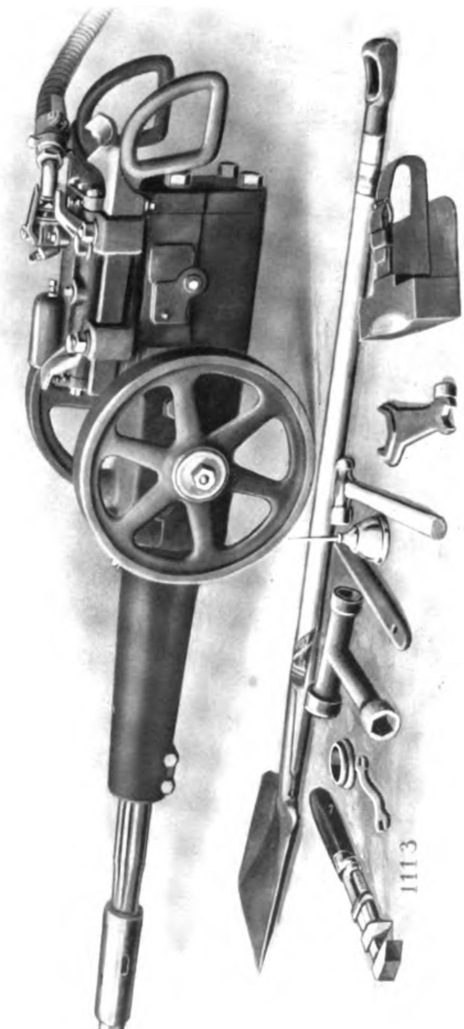
INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Form No. 5002 April, 1910

THE "New Ingersoll" Pick Machine or Puncher, operating by compressed air, does the work of six to fifteen skilled pick miners in undercutting. Its greatest field is in horizontal seams. But it is also adapted for undercutting in pitching seams, the angle of which does not exceed ten, or occasionally fifteen, degrees from the horizontal. For seams of greater pitch, the Company has the "Radialaxe" Coal Cutter, to which a separate pamphlet is devoted.

"New Ingersoll" Coal Puncher at Work in the Tennessee Coal Company's Mines, Briceville, Tenn.



The "New Ingersoll" Coal Puncher, with Complete Equipment

About Machine Mining

While varying local conditions forbid any definite statement of the work which a coal mining machine will do, it can be stated as a fact, based on the widest experience, that the pick machine has a marked advantage over hand mining on the following grounds: lower mining cost, due to the fact that the greater cutting capacity of the machine will maintain a given output with a lower labor cost, or a greater output with a given labor cost, even when interest, depreciation, "differentials" and operating costs are charged against the machine; improved quality of the output, brought about by the deeper and more uniform undercut of the machine, which increases the percentage of lump coal 10 to 25 per cent over hand mining methods; more rapid development, due to the much greater speed with which entries can be driven by the machine; reduced number of working places for a given daily output; greater safety, because the deep machine undercut permits more coal to be brought down with a smaller powder charge, reducing the danger from explosions attendant upon a "blown-out" shot.

Other advantages incidental to the use of the air puncher are: compressed air in the mines is available for rock drilling, pumping, hoisting, etc.; lessened danger to the miner, who is never exposed to a fall of coal in undercutting; improved labor conditions, as the miner is freed from much disagreeable work, and can get a larger tonnage with a machine than by hand; improved ventilation by the exhaust air; the possibility of furnishing air to entombed miners, in case of accident, or of delivering water through the air pipes to the coal faces in case of fire.

It is unnecessary to enter here into a discussion of these several points. The hundreds of mines in every part of the country in which these facts have been demonstrated are the best argument in favor of machine mining as against hand methods. The present pamphlet presents the important exclusive features of the "New Ingersoll" Puncher, which explain the fact that this particular machine assures the operator of securing these highly desirable results in higher degree than with any other pick machine. There are single customers using more than 500 "New Ingersoll" Punchers, and hundreds of mines using from five to fifty of these machines. This is conclusive proof of their legitimate claim to superiority. The following discussion of details emphasizes those features which explain this wide-spread popularity.

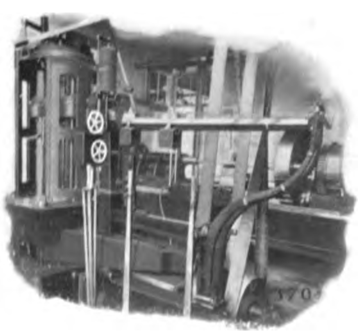
General Design

The design is rugged, powerful and well balanced. Moderate weight is combined with great strength by the use of selected materials of superior quality. The type represents the acme of simplicity, in itself a protection against heavy repair charges, due to frequent breakage of delicate parts.

Material

Whatever the kind of material, only one *quality* is used in the "New Ingersoll" Puncher — *the very best.* The Company's careful study of the machine in operation under all conditions has enabled it to carefully gage the strains, shocks and accidents to which each part is subjected or liable, and to provide for adequately meeting them. Only that grade of material is used which experience and test have shown to be best adapted to each individual demand. Special grades of metal are selected because of some peculiar adaptability to the case in hand. The best high-carbon steel is employed, the percentage of carbon varying with the requirements, giving a steel harder, tougher, stronger and more durable, with a higher elastic limit. Double refined and malleable iron are applied where best suited. The object of this careful selection of materials is to produce, so far as possible, a machine of uniform and maximum wearing quality throughout.

Oil Treating Department



Material Testing Room

Steel Treatment

The highly specialized process of improving steel by oil-treating and annealing has

been carried by the Ingersoll-Rand Company to a higher degree than by any other manufacturer. The system used is as thorough as, and in many respects is identical with, that used by the United States Government for ordnance forgings. In brief, the method consists in heating the steel after rough turning or machining to a certain exact temperature, then plunging it in an oil bath, where it cools. It is then put in an annealing furnace, where all cooling strains are relieved and the metal fibers allowed to adjust themselves to a condition of equilibrium throughout the part. The result is a tensile strength increased 25 to 30 per cent over that of steel not so treated; and, in addition, all lurking weaknesses due to internal stresses in forging, straightening or cooling are removed. The elastic limit is increased, also, and the metal left tough and in the best possible condition to resist shocks, strains and wear.

Workmanship

Only skilled workmen of the highest class are employed in the production of "New Ingersoll" Coal Punchers, and the organization

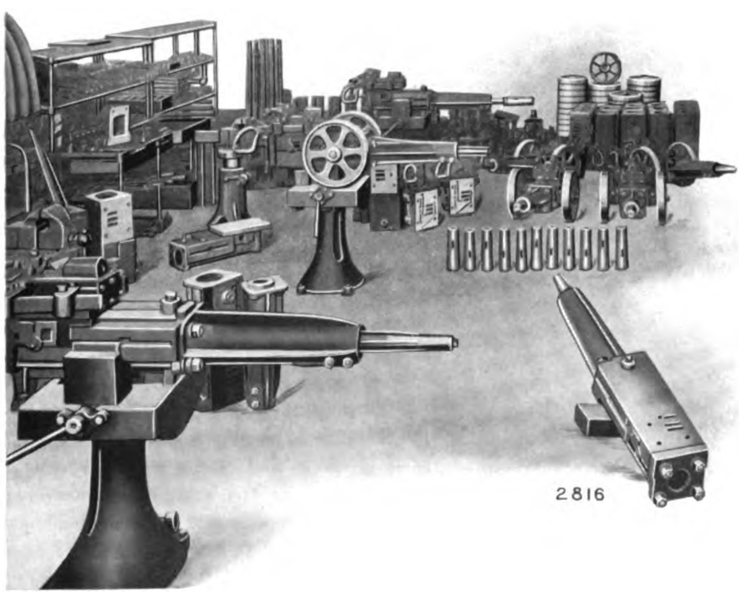
Breaking Rooms in an Entry with a "New Ingersoll" Coal Puncher at the Adrian Mine of the Rochester C. & T. Company

A Group of "New Ingersoll" Coal Punchers Complete and Ready for Stock, Showing Method of Building in Quantities Resulting in Interchangeability of Parts

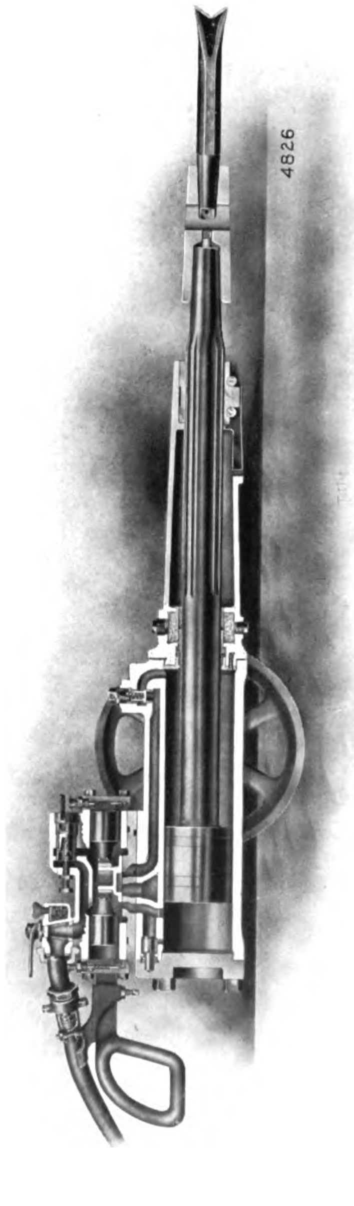
is such that it is to the interest of every employee to strive after an improvement in his product and a betterment in the character of his work. Personal supervision and inspection is carried to a point where the utmost care and precision is enforced in every element of workmanship. A valuable detail of the tooling process is that, wherever possible, grinding is used for the finishing cut instead of turning, milling or planing. This gives a smoother, truer surface, assures absolute accuracy and more closely fitted joints, and the maximum strength of parts. No packing or gaskets are used on "New Ingersoll" machines, all joints being "metal to metal."

Interchangeability

"New Ingersoll" Punchers are not built as individuals. The illustration opposite shows a typical shop run, each machine of which has been tested and is ready for shipment. Moving parts are built and finished in lots of hundreds, though each part is separately inspected and measured by a system of limit gages, guaranteeing duplication. Automatic machine tools eliminate, so far as possible,



A Corner of the Coal Cutter Assembling Room



Longitudinal Section of "New Ingersoll" Coal Puncher

the "personal factor" in the manufacturing process and assist in the production of parts of dimensional uniformity. A corner of the coal cutter assembling room is shown on page 7, with machines in various stages of completion and parts in quantity at hand.

Limit Gage Test

The system of test by limit gages is an interesting example of the degree of refinement to which Ingersoll-Rand methods have been carried. For such coal cutter parts as piston and valves, two outside ring gages are provided. These are of hardened and ground steel, the diameter of the opening in one being one one-thousandth of an inch larger than that in the other. One must pass over the part under inspection, the other must not. For bored parts, such as cylinders and valve chests, two plug or inside limit gages are used in a similar manner.

No other manufacturer of coal cutters uses this system or anything even approaching it in accuracy. This perfect interchangeability is of vital importance in coal cutters, so often used where repair shop facilities are lacking. A worn or broken part can usually be replaced without taking the puncher from the mine. When repair parts are ordered for the "New Ingersoll," it will be with the assurance that they will fit in place absolutely; and the machine in that element will be as good as new.

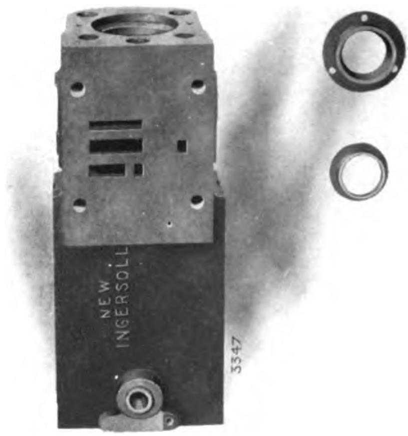
While every possible precaution is taken, in "New Ingersoll" Punchers, to guard against frequent necessity for repairs, yet even the best machines may meet with accident, or suffer under neglect or abuse. Duplicate repair parts of these machines are always in stock at shop or branch office, and this, with this limit gage test, provides "parts that fit" subject to quick delivery on demand. An outfit of punchers should usually have a small stock of duplicate parts at hand.

Running Test

Each "New Ingersoll" Puncher is not only completely assembled at the shop but is there given a running test under conditions as nearly those of actual service as it is possible to approximate in the test room. Its performance is noted, any imperfections which may appear are corrected and all adjustments are correctly made. Each machine goes from the test room to shipping department in perfect condition and ready for its maximum performance.

The Cylinder

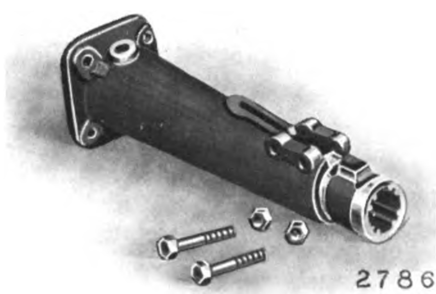
The cylinder is cast of a tough, close-grained charcoal iron, by a process which assures absolute uniformity of quality. Proper lubrication produces in the bore a hard, glass-like surface, which shows little or no wear in service. Ports are ample and direct. The machining on faces and sides is extremely accurate. Proper reinforcement at points of maximum stress gives great resisting power without undue weight.



Cylinder of "New Ingersoll" Coal Puncher

The Front Head

The front head of the "New Ingersoll" is a steel casting slightly conical in shape. This gives the strongest possible design and provides against breakage of this vital part, so exposed to injury from falls of coal or slate. As will be seen in the illustration, the front end of the head carries a heavy boss with a slot, which receives a thick lug on the phosphor bronze bushing, preventing the latter from turning. This bushing has teeth or tongues accurately engaging flutes on the piston rod, preventing the rotation of the piston. Two strong clamp bolts hold it in place, providing, however, a quick and ready means of releasing and removing it without taking the machine from the cutting board. This front head bushing is a very important



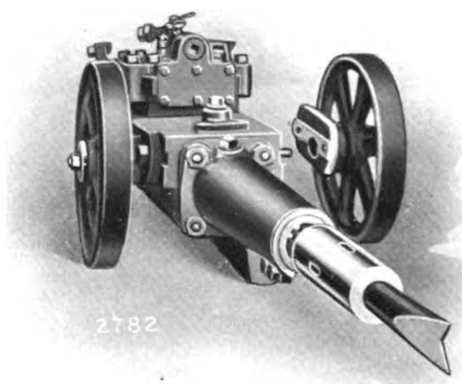
Front Head of "New Ingersoll" Puncher

feature, which should be carefully compared with other constructions in order to appreciate its superiority.

Babbitted heads when worn must be removed and taken to the shop where they are weakened by being heated to melt out the old babbitt. They must then be rebabbitted over a mandrel. Meanwhile the machine is out of commission for a day, or perhaps more, and the tonnage is lost during that time. For these reasons the use of babbitted heads has been abandoned by this Company after a fair trial, as being inferior to high-grade bronze.

The Wheels

The wheels used on the "New Ingersoll" are heavy and strong, of malleable iron, with the strength and rigidity so necessary for this work. The rim of the wheel has a broad, flat surface, giving the greatest durability and less jar on the operator. Special large wheels for shearing can be furnished on order in place of the smaller standard wheels.



Showing Method of Adjusting Trunnion

The Trunnions

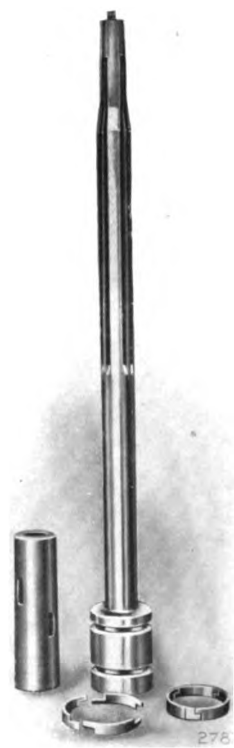
The accompanying illustration shows a wheel and trunnion detached from the cylinder, while that on the next page shows the two separately. It will be noted that the trunnion is held in position by two heavy bolts, the T-shaped heads of which are held in a long slot, permitting the trunnion to be readily moved backward and forward by merely loosening the nuts. This adjustment of the wheels is of the utmost importance, as it permits balancing the machine. When the cutting picks are new they are longer and heavier, and the machine should be balanced to meet this condition as well as the personal

Wheel and Trunnion of "New Ingersoll" Puncher

preference of the runner. When the length of the pick changes, a new adjustment is desirable. When cutting against a pitch, over a roll, or through local dips, this method of adjusting the trunnions shows its real value in meeting the conditions perfectly.

The trunnion or axle proper on the "New Ingersoll" is about twice as large as that on any other puncher. The necessity for this was proved in a long experience, showing that small trunnions cast in the cylinders are subject to most disastrous wear and tear, which in a few months resulted in a machine which wobbled in the hands of the operator, giving rise to endless annoyance.

When this condition occurred there was nothing to be done but to buy new wheels and axles, or even cylinders. "New Ingersoll" trunnions are built to last for years, and their extra large bearing surface results in a much steadier, easier running machine. When it becomes necessary, for any reason, to renew a trunnion, a new one can be substituted without loss of the cylinder which will probably be equal to much longer service. The wheel is held on its trunnion by a washer clamped tight against the trunnion face by a central screw.



Piston, Piston Rings and Extension

The Piston

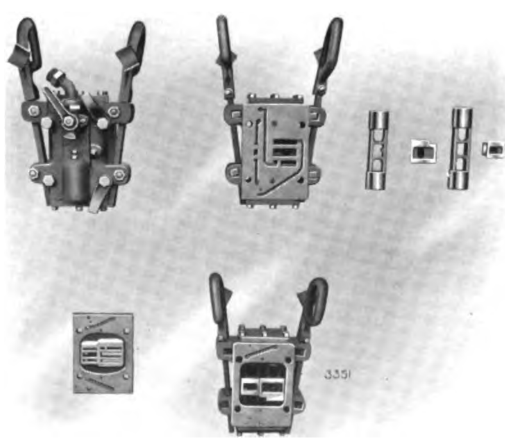
The piston of the "New Ingersoll" is forged solid from a very tough quality of steel. The rod is accurately fluted from the front end for the full length of the piston travel, these flutes engaging corresponding flutes in the front head bushing. The piston carries two packing rings, each made in three sections, forced outward by expansion springs within. These are carefully fitted to an air-tight joint. The exceptionally long front head bearing of the piston rod avoids the possibility of breaking the latter when the pick strikes a glancing blow on a hard surface. The chuck or extension is a heavy sleeve of steel with an inside taper at both ends. One end slips over a taper on the piston rod, the other receives the tapered shank of the pick. Both joints are relieved by driving in a drift key through slots in the chuck provided for this purpose. All these parts are oil-treated and superior to "nickel steel."

The Valve Chest

The valve chest is a strong casting with the face accurately machined. On the sides of the chest lugs are provided through which the handles slip, and a bolt adjustment is provided at this point. The valve chest cover carries the throttle and governor valve. Between the valve chest and cylinder a plate is interposed in which the ports are milled. Heavy steel bolts bind these three parts and the cylinder together, with the solidity of a single casting.

The Valve Movement

The valve movement of the "New Ingersoll" is positive and absolutely inde-



Details of "New Ingersoll" Valve Movement

pendent of the travel of the piston. Its essential parts are two "spool" or plunger valves, air actuated, ground to a plug fit in the chest and each carrying a D-valve. One is the "auxiliary" valve, its movement governing that of the other, or "main" valve, which in turn controls the admission and exhaust to the cylinder. The movement of these two valves is reciprocal; *i.e.*, there is no "dead center," and the valve action cannot stop so long as air is admitted through the throttle.

This is the most simple, most positive and most durable valve movement on the market, having only four moving parts. The plungers cushion on air. The arrangement operates with the least possible friction and wear, and there is nothing about it to get out of order. Instances are on record where "New Ingersoll" Punchers have operated for years without opening the valve chest.

Pulling-out Power

Even when the pick sticks and the piston stops, the valve movement continues, the alternate impulses on either piston face quickly working it loose, being in the nature of a powerful "jerk and push" on alternate faces. The back port of the main valve is larger than the other, meaning that the forward blow is much quicker and heavier than the backward pull, and showing that the question of economy has been carefully considered, less air being used for the return stroke.

Control of the Blow

Two small screws are provided on the valve chest, their function being to regulate and govern the speed of the auxiliary valve which, in turn, controls the movement and speed of the main valve. This is accomplished by varying the amount of air admitted to either end of the auxiliary valve plunger. By this means the operator is able to accurately adjust the action of his machine to suit his convenience and the conditions under which he works. However, while these regulating screws perfectly control the speed of the main valve, and thus of the entire machine, a change in their adjustment need have no influence upon the force of the blow, for when the main valve moves at all it covers its whole travel, opening the main ports wide and admitting full pressure to the piston. The force of the blow may be as heavy as is desired, whatever the speed.

Governor Valve

The front and back cylinder heads are fully protected by air cushions. Assume the piston on its forward stroke, live air being admitted through the main back port. The piston will travel forward, pass the main forward port and close it. At this point normally the pick will strike the coal. If for any reason the pick misses the coal, the piston will continue its movement, compressing the air in front of it against the front head. As the piston advances, this cushion pressure momentarily rises above working pressure and communicates through a small passage to the face of a governor valve, automatically shutting off air from the entire machine. It is not necessary, however, that this governor valve shall entirely shut off the air. Its stop can be adjusted so that the air passage is not entirely closed. Under such conditions the machine will run lightly, at a reduced speed and force, until the pick is again thrown against the coal, when, the cushion pressure being relieved, the governor valve automatically opens and the machine is brought into instantaneous action with full pressure and force.

No Deadly Kick Possible

This governor valve introduces an element of safety which is afforded in no other puncher. It removes all possibility of the deadly kick of the ordinary puncher, which so often results in injury to the runner, with the damages or pension involved. Just what causes this "kick" or recoil in other styles of pick machines will be readily appreciated. With other valve movements, dependent for their action upon some connection with the piston, when the pick sticks the cylinder becomes the reciprocating part. The machine will be pulled down on the board until the piston is at the back end of its stroke, when air is suddenly admitted at full pressure, throwing the machine backward with great force — oftentimes entirely clear of the board.

For these reasons the "rifle bar" valve drive or control has been abandoned in "New Ingersoll" Punchers. Manifestly such an accident as this is impossible with the "New Ingersoll" movement. The automatic governor valve is particularly appreciated by new men just learning to run the machine, as it gives them protection against injury. The throttle can be opened wide and left so during a whole running period, with the assurance that the governor valve will

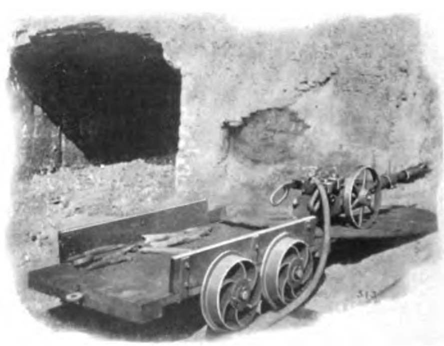
"New Ingersoll" Coal Puncher Ready to Start

take care of the supply at all times and under all conditions. Experienced men who swing the machine or the pick away from the coal less frequently and are sure of themselves, can, if they desire, throw the governor entirely out of gear.

Although live air passes the main valve at each stroke, in order to enter the cylinder this air must first lift a small valve against spring pressure and against the cushion pressure in the cylinder. As this can be done only when the cushion pressure is below live air pressure, live air cannot be admitted until the back stroke of the piston has been started; hence the cushioned or trapped air aids the "pull back" and economizes air.

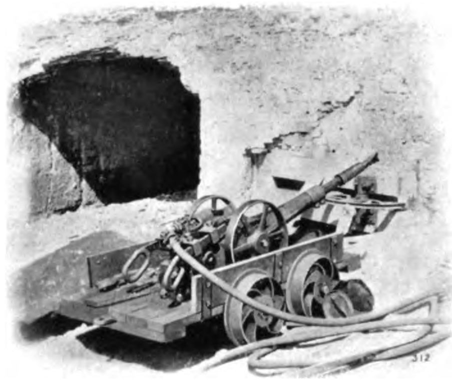
Adaptability to Low Pressures

One of the most remarkable and most valuable features of the "New Ingersoll" is its capacity for doing work on pressures so low that other punchers lose their effect or stop entirely. This is due to the unique valve movement, which is automatically self-adjusting to varying pressure conditions. A valve movement dependent upon the travel of the piston cannot have this quality. Such machines have a fixed point of cut-off inadequate at low pressures, and when the piston



"New Ingersoll" Coal Puncher Ready to Load

stops the valve stops — and the machine is "dead." In the "New Ingersoll," on the contrary, when the main valve moves at all it covers its whole travel and the ports remain full open for the entire stroke. The valves will operate on even the lowest pressures and the full pressure — whatever it may be — is admitted to the cylinder for the full stroke. The result of this is that the "New Ingersoll" has an effective pressure range of from 40 to 100 pounds, while "dependent valve" machines become inoperative at 65 or even 75 pounds unless specially designed for the lower pressures. It is this peculiar and valuable quality in its valve mechanism which has won for the "New Ingersoll" its reputation as an "all-around" puncher.



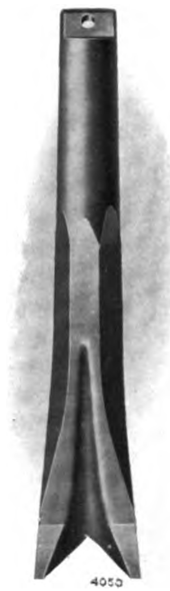
"New Ingersoll" Coal Puncher Ready to Move

The true meaning of this wide range of effectiveness in the "New Ingersoll" will be appreciated by practical mining men. A "puncher" plant is usually installed to meet immediate conditions. But conditions change; the workings become deeper and more extensive. Pipe lines, originally adequate to the demands, grow inadequate as distances increase, resulting in a lowered pressure at the distant face or heading. Another condition conducive to lowering air pressure arises where a compressor plant is overloaded, as the property grows, by the addition of more punchers or pumps than were originally intended. The "New Ingersoll" is the only puncher meeting these conditions, by virtue of its positive valve movements which adapts itself to all pressures. It assures the mine operator against loss of machine output as distances increase and pressures diminish.

The Picks

The pick for the "New Ingersoll" is of round or octagon steel, tapered at one end to fit in the chuck or extension. The other

end is flattened and swedged out in the center on one side, the center being cut in the form of a V, leaving the bit with double points. The swedging is all done on one side of the pick and in moderately soft coal care should be taken that the pick points, when dressed, squared up and tempered, are lined up with the piston rod with the points from one-fourth to three-eighths of an inch off the center line.



"New Ingersoll" Pick

In very hard coal it is necessary to flatten both sides of the pick, bringing the points nearer to the center line. The pick should be invariably dressed up to a cutting edge in the crotch, and the two points dressed square in the same manner as a miner's pick, except that they should be made larger in order to stand the heavier blow of the machine. Although the double-pointed pick just described is the one most commonly used, it is sometimes necessary to change the shape of the pick to meet local condition. But this can be determined only by experience.

Sizes and Capacities

The table on page 21 gives all the essential data relating to the various sizes of the "New Ingersoll" Puncher. A few remarks may not be out of place, however, by way of distinguishing the several sizes and outlining the work for which they are adapted.

The F-4 "New Ingersoll" is a light machine, weighing approximately 586 pounds and undercutting to a depth of four feet six inches. On account of its light weight this machine can be operated on a very flat board and is capable of doing very good work in a three-foot seam. It has also been successfully used in seams having a pitch of twelve to fifteen degrees. It is not suitable, however, for very hard coal.

The H-7 "New Ingersoll" is adapted for harder coal. It weighs 675 pounds, or 89 pounds more than the F-4 machine; but having a larger cylinder diameter it strikes a much harder blow and has an

undercutting capacity of five feet. This machine is not only successfully used in low seams but it has also become a great favorite in seams of average thickness, because of its lightness, large productive capacity and easy running qualities.

The H-4 "New Ingersoll" is intended for those who prefer a heavier machine. It weighs 835 pounds and is suitable for undercuts of five feet in depth in seams of a thickness of five feet or more. It cuts equally well in soft, medium or hard coal, its blow being under perfect control at the hands of the operator.

The H-10 "New Ingersoll" is lighter than the H-4, weighing only 775 pounds; but, having a 5½-inch cylinder, it strikes a much harder blow and is designed for use in very hard coal where a powerful blow is essential. Its undercut is five feet deep.

The H-12 "New Ingersoll," weighing 850 pounds, is the heaviest

Completing an Undercut with a "New Ingersoll" Coal Puncher in a Mine in Pennsylvania

machine on the list, adapted for work in thick, very hard seams. Its undercut is six feet in depth.

All of these machines, it will be noted, can be furnished in either wide or narrow gauge; and they can also be supplied with shearing wheels.

The Company is also prepared to furnish all necessary accessories for the puncher, such as picks, air hose, etc.

The Ingersoll-Rand Company has unequaled facilities for turning out mining machines and meeting demands quickly and satisfactorily. The illustration on page 6 gives some idea of the Company's ability to give its customers immediate service. The machines are built in the various sizes listed to meet a variety of conditions throughout the country. The Company has made a careful study of the requirements in different coal fields and has spared neither effort nor money in producing a line of machines which will meet the demands of both manager and machine runner. The latter is one of the most important factors in successful machine mining, and the Company has succeeded in perfecting a line of punchers so easily handled and so simple in design that they have been most heartily endorsed by organized labor.

The "New Ingersoll" Coal Puncher in Operation at the Mines of the Nuren Coal Company at Baden, Illinois

Descriptive Table of "New Ingersoll" Coal Punchers

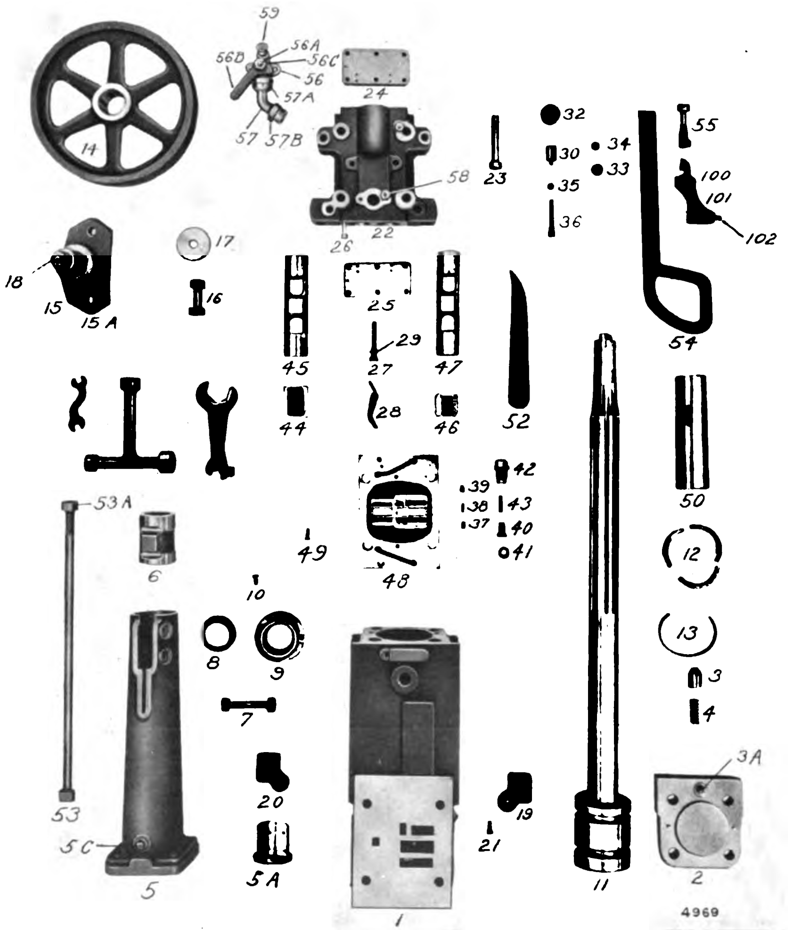
Dimensions and Weights of Coal Cutters

Style and Symbol	With Complete Equipment and with 10 Picks and 50 Feet Hose	Complete Equipment without Picks or Hose	Size			Dimensions, including Extensions and Picks					Size of Under Cut			Weight in Pounds				
	Telegraph Name	Telegraph Name	Diameter of Cylinder, Inches	Length of Stroke, Inches	Diameter of Stand ard Wheels, Inches	Gage Outer Rim of Wheels, Inches	Width Over All, Inches	Maximum Length, Feet and Inches	Minimum Length, Feet and Inches	Height from Floor to Top of Chest, Inches	Depth, Feet and Inches	Width, Feet and Inches	Possible Center Depth, Ft. and Ins.	Machine, including Extension	15-inch Pick	Extension	*Equipment Complete	Gross Shipping Weight
F-4 Wide Gage	Kreitsen	Kresshuhn	4½	14	14	19½	22½	8-0	6-9	18⅝	4-6	5-0	5-3	586	8½	16	65	795
F-4 Narrow Gage	Kremling	Kressling	4½	14	14	16½	19½	8-0	6-9	18⅝	4-6	5-0	5-3	586	8½	16	65	795
H-4 Wide Gage	Krenkers	Kretscham	5	17	17	21¼	24¼	8-6	7-0	20⅛	5-0	5-0	5-9	835	8½	20	65	1045
H-4 Narrow Gage	Krenksters	Kreubeere	5	17	17	18¼	21¼	8-6	7-0	20⅛	5-0	5-0	5-9	835	8½	20	65	1045
H-7 Wide Gage	Krenkten	Kreukelde	5	17	16	21¼	24¼	8-6	7-0	19¾	5-0	5-0	5-9	675	8½	16	65	885
H-7 Narrow Gage	Krensauer	Kreupel	5	17	16	18¼	21¼	8-6	7-0	19¾	5-0	5-0	5-9	675	8½	16	65	885
H-10 Wide Gage	Krenterig	Kreusmes	5½	17	17	21¼	24¼	8-6	7-0	21¼	5-0	5-0	5-9	775	8½	22	65	985
H-10 Narrow Gage	Kreppende	Kreuzaltar	5½	17	17	18¼	21¼	8-6	7-0	21¼	5-0	5-0	5-9	775	8½	22	65	985
H-12 Wide Gage	Kreppflor	Kreuzarche	5½	17	17	21¼	24¼	9-6	8-0	21¼	6-0	6-0	6-10	850	8½	22	65	1080
H-12 Narrow Gage	Kresse	Kreuzarm	5½	17	17	18¼	21¼	9-6	8-0	21¼	6-0	6-0	6-10	850	8½	22	65	1080

Shearing Wheels

Style and Symbol	Electric Welded Steel Rim with Steel Spokes and Hub		
	Diameter, Inches	Weight Each in Pounds	Telegraph Name
F-4 Wide Gage	30	76	Kreuzbaum
F-4 Narrow Gage	32	78	Kreuzbild
H-4 Wide Gage	36	89	Kreuzbinde
H-4 Narrow Gage	38	95	Kreuzblume
H-7 Wide Gage	40	98	Kreuzbogen
H-7 Narrow Gage	42	102	Kreuzbrav
H-10 Wide Gage	44	106	Kreuzdohle
H-10 Narrow Gage	46	114	Keeuzdorn
H-12 Wide Gage	48	120	Kreuzdumm
H-12 Narrow Gage	50	131	Kreuzen

* These weights cover the Extension, Wrenches. Oil Can, Hammer and Shovel, Boxed. Hose and Picks are not included.



Duplicate Parts of "New Ingersoll" Coal Punchers

Duplicate Part List

"New Ingersoll" Coal Puncher

Number and Name of Part. All Sizes

Cylinder Complete

1 Cylinder
19 Exhaust Door, R.H.
20 Exhaust Door, L.H.
21 Exhaust Door Trap Bolt (2)
37 Governor Check Valve
38 Governor Check Valve Spring
39 Governor Check Valve Plug
40 Main Check Valve
41 Main Check Valve Seat
42 Main Check Valve Cap
43 Main Check Valve Spring

Front Head Complete

5 Front Head
5A Front Head Oil Bushing
5B Front Head Oil Plug (Top*)
5C Front Head Oil Plug (Bottom)
6 Front Head Bushing
7 Front Head Bushing Bolt (2)
8 Front Head Cup Leather
9 Front Head Cup Leather Washer
10 Front Head Cup Leather Washer Screw (3)

Trunnion Complete

15 Wheel Trunnion (wide gage) (2)
15A Wheel Trunnion (narrow gage) (2)
16 Wheel Trunnion Bolt and Nut (4)
17 Wheel Trunnion Washer (2)
18 Wheel Trunnion Stud and Nut (2)

Chest Complete

22 Valve Chest
23 Valve Chest Tap Bolt (4)
24 Valve Chest Cover (Front)
25 Valve Chest Cover (Back)
26 Valve Chest Cover Tap Bolt (12)
27 Regulating Screw and Cap (2)
29 Regulating Screw Gland (2)
30 Governor Valve
31 Governor Valve Bushing*
32 Governor Valve Plug
33 Governor Valve Cup Leather
34 Governor Valve Cup Leather Washer
35 Governor Valve Cup Leather Washer Nut
36 Governor Valve Adjusting Screw and Nut
44 Main Valve
45 Main Valve Plunger
46 Auxiliary Valve
47 Auxiliary Valve Plunger
48 Valve Seat
49 Valve Seat Screw (2)
55 Handle Bolt (4)
58 Throttle Valve Stud and Nut (2)

Piston Complete

11 Piston
12 Piston Ring (2)
13 Piston Ring Spring (2)

Throttle Valve Complete

56 Throttle Valve Body
56A Throttle Valve Plug
56B Throttle Valve Handle
56C Throttle Valve Plug Nut (2)
57 Throttle Valve Elbow
57A Throttle Valve Connecting Sleeve
57B Throttle Valve Spud
57C Throttle Valve Connecting Sleeve Gasket*
59 Throttle Valve Thumb Screw

Miscellaneous Parts

2 Cylinder Back Head
3 Cylinder Back End Check Valve
3A Back End Check Valve Guide
4 Cylinder Back End Check Valve Spring
14 Wheel (2)
28 Regulating Screw Guard (2)
50 Extension
52 Drift Key
53 Through Bolts (4)
53A Through Bolt Nuts (4)
54 Handle (2)
100 Hose Rest, R.H.
101 Hose Rest, L.H.
102 Hose Rest Set Screw

NOTE. — Number following name of part, thus (2), shows number required on a complete machine. In ordering parts, the symbol designating the size of the machine should be given, as well as the number and name of the parts wanted.

Parts marked * not shown in cut.

After a Blast in the Greensburg, Pennsylvania, Mine No. 2, of the Keystone Coal and Coke Company. The Coal was Undercut with a "New Ingersoll" Machine, and the Large Percentage of Lump is to be noted

GRIFFITH - STILLINGS PRESS

"RADIALAXE"

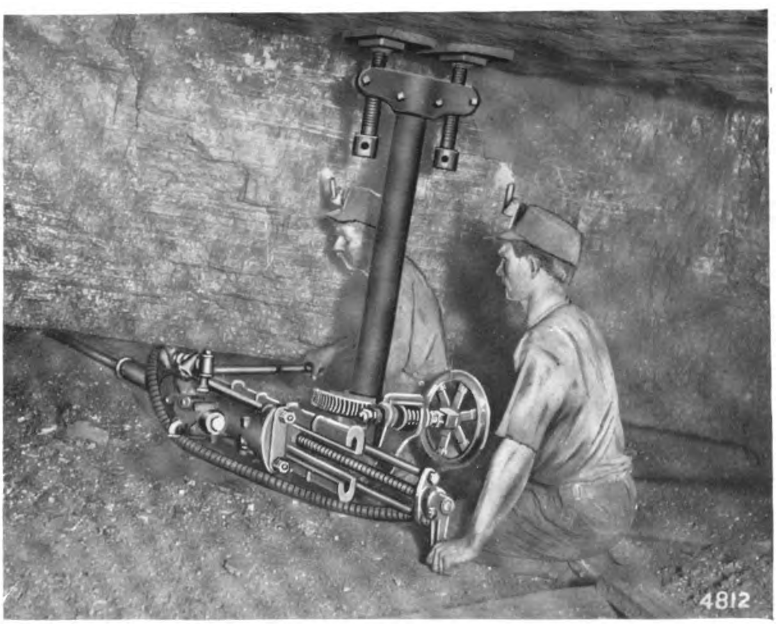
AIR DRIVEN COAL CUTTERS

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Form No. 5003. December, 1910

THE "Radialaxe" Coal Cutter has six classes of work for which it is distinctly adapted and in which it has no successful competition. These are: undercutting in a pitching seam; shearing in any seam and particularly in entries; mining near the middle of the seam; cutting out veins or bands of fire clay or slate in the coal seam; mining under or above such seams so that the dirty material can be loaded out without mixing with the coal; driving entries or headings.



"F-92" "Radialaxe" undercutting in a pitching seam.

Shearing a Room Face with the "Radialaxe."

It is a special machine designed for a special line of work, developed out of the Company's large experience in building rock drills and coal cutters. The "Radialaxe" is, in fact, an adaptation of the rock drill principle to certain classes of work encountered in coal mining under modern conditions. It has the standard Ingersoll-Rand rock drill quality in design and construction.

Undercutting in a Pitching Seam

No puncher can successfully undermine in a seam of coal with a pitch exceeding 15 per cent. With a pitch greater than this the "Radialaxe" is the only mining machine which can be profitably used. While punchers have been used on these higher pitches, the work has been very hard on the operator and the rate of cutting has been very low.

The "Radialaxe" is adapted for undercutting in pitches of from 15 to 40 per cent. As a matter of fact, it has been used in seams with a much greater pitch than 40 per cent. However, anything above the latter is generally a straight blasting proposition, undermining of any kind seldom being attempted. For pitches up to 15 per cent. the "New Ingersoll" Puncher is to be preferred and is recommended by the Company.

Shearing

As a shearing machine the "Radialaxe" has no equal. It is true that in America shearing has not yet assumed the importance which it merits. But it is rapidly becoming recognized as almost as important as undermining, for it is well known that the majority of explosions in coal mines are directly traceable to blown-out shots. In almost every instance this would not have occurred had the rib been sheared before blasting, for very often dust or gas explosions are caused by a shot hole drilled in the "fast." In Great Britain this element of danger was recognized years ago and the conditions giving rise to it are now prevented by Act of Parliament.

Aside from the possible arguments on this question, however, there are many cases where shearing is a necessity; for instance, in seams

where the pitch is heavy and headings are sheared before blasting. There is no doubt that this can be done more rapidly and more cheaply with the "Radialaxe" than by any other means.

Wherever coal is blasted off the solid the "Radialaxe" is invaluable, for shearing a cut in the middle of the face permits blasting toward the center on open ends. This makes blasting 50 per cent. more effective, saves one third the powder cost, and makes more and better coal with less smoke and with less danger of explosions. It can be readily seen that in shooting from an open or loose end, the action of the powder can be better gaged and the charge so placed that there will be little danger of a blown-out shot, little liability of knocking out props, and a large percentage of good, hard, solid lump coal instead of a lot of powder-shattered slack. In average shearing work the "Radialaxe" easily shears 25 to 30 lineal feet of heading per day and saves considerable yardage.

Cutting Out a Clay Band with the "Radialaxe."

Mining in the Middle of the Seam

In driving dip entries there is often an accumulation of water which makes mining at or near the bottom an impossibility. In such cases the "Radialaxe" can be used to mine in the seam at any point above the water level and in this way more rapid progress is made.

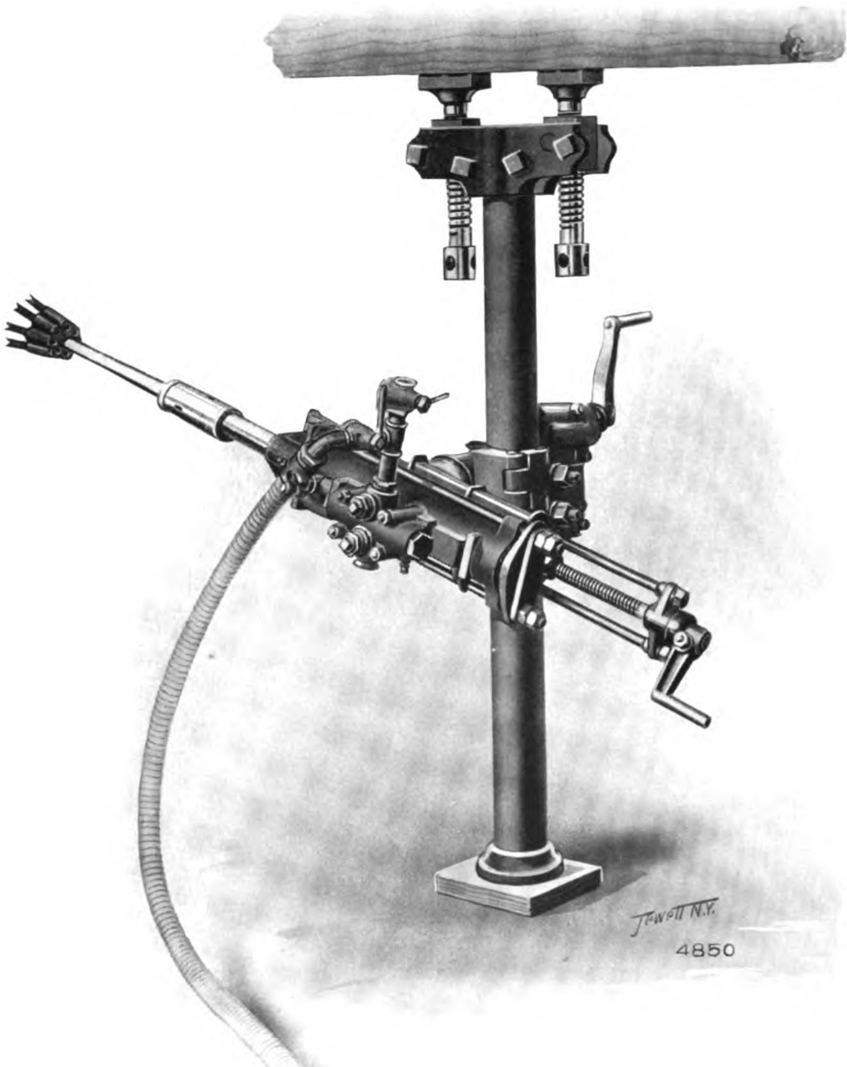
Cutting Out Bands in the Coal

The "Radialaxe" surpasses all other machines where a fire clay or slate band is to be removed in the face of a seam of coal. These bands generally run as regularly and persistently as the coal itself and they may occur in any part of the seam. When the coal is undermined in the usual way and shot down, these impurities are so mixed that it is impossible to load out the coal clean. Market conditions are such that dirty coal is condemned or commands a lower price. Although the coal itself may be first-class, it is rejected or must be sold at a lower figure because of the slate or clay which it contains.

The "Radialaxe" offers two solutions of the problem of getting rid of this dirty material. Where it is of a hardness not exceeding that of the coal itself, the band may be simply mined out, after which the entire seam is undercut and mined in the usual way.

Where the dirty material is too hard for this the coal must be mined out under or above the band. Assume a coal seam six feet thick with a six-inch band of hard fire clay four feet from the floor, giving a bottom coal bench of four feet and an upper bench of eighteen inches. By using the "Radialaxe" for undermining in the coal directly under the band, and then shearing one side, one or two small shots will blast out this bottom bench and it can be loaded absolutely clean.

In many cases the slate or clay remaining will drop or can be taken down before the top bench of coal is removed. If this cannot be done, the top bench with the band under it can be blasted down at one time. If this is done intelligently the impurities will be underneath, with the clean coal on top; and the latter can then be loaded out without touching the dirty material. In this way all the coal in the seam can be mined out and marketed as first quality.



The Standard "F-92" "Radialaxe" on the "G-48" Type Shearing Mounting

Entry Driving

The driving of entries and headings calls for a rapid and reliable shearing machine, and this is distinctly the work for the "Radialaxe." By its use entries can be driven much more rapidly and cheaply than by other means. The actual rate will vary with the local conditions, but speeds two or three times as fast as hand methods are not unusual. The yardage saving may amount to from $3.00 to $15.00 per day.

Used as a Rock Drill

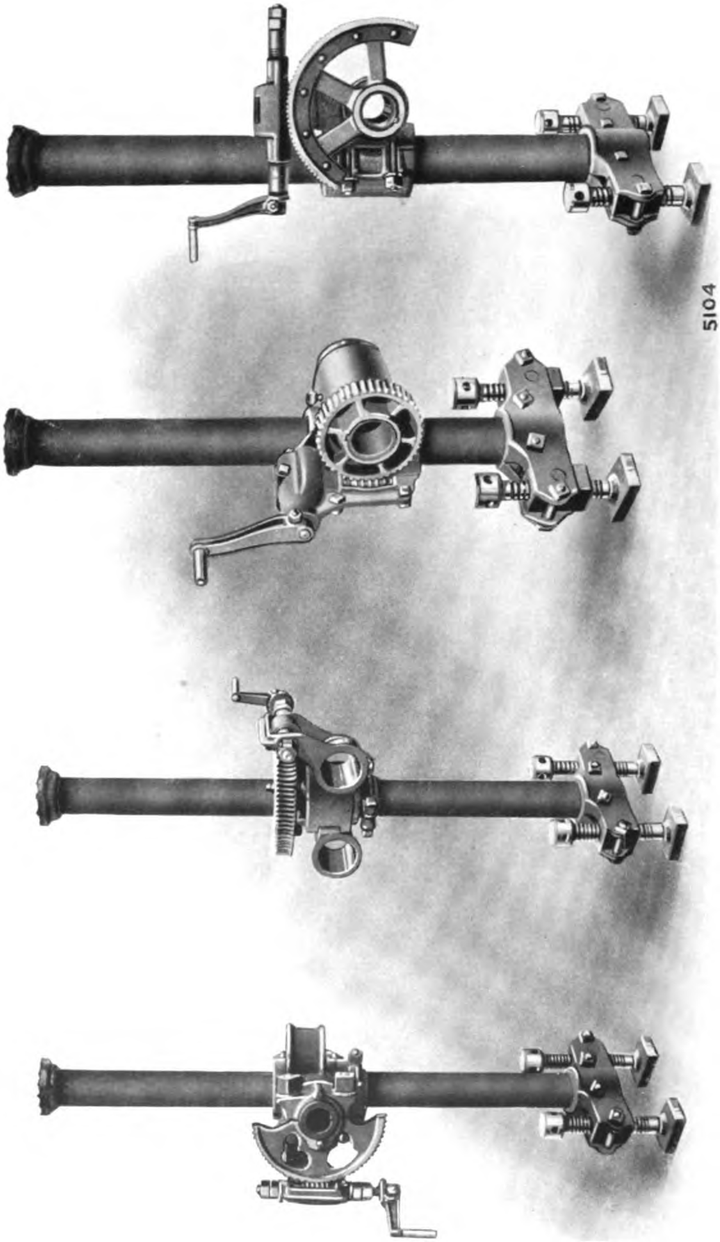
Beside the lines of work just described in which the "Radialaxe" has no successful competition, the machine when used as a rock drill is a most valuable accessory to the coal mining plant. Some of its applications along this line are as follows: taking down roofs; taking up floors; cutting through rock faults; brushing entries; cutting refuge places; sinking shafts, sumps, etc.; driving rock headings; cutting through rolls or horse-backs; general development. In this work the "Radialaxe" has all the speed and reliability of the standard rock drill.

Ease of Operation

The light weight of the "Radialaxe" as compared with the puncher or chain machine, appeals strongly to the runners, and experience has shown that it is easy to secure and hold good operators for this machine. Its operation is easy on the runner and the facility with which the outfit breaks up into comparatively light sections for moving and setting up is another strong factor in its popularity among the miners.

General Description

The "Radialaxe" is in essentials a long-stroke rock drill provided with a method of mounting especially adapted for the class of work for which it is intended. In appearance it is very similar to the standard Ingersoll-Rand rock drill. In fact, it is simply a modifica-

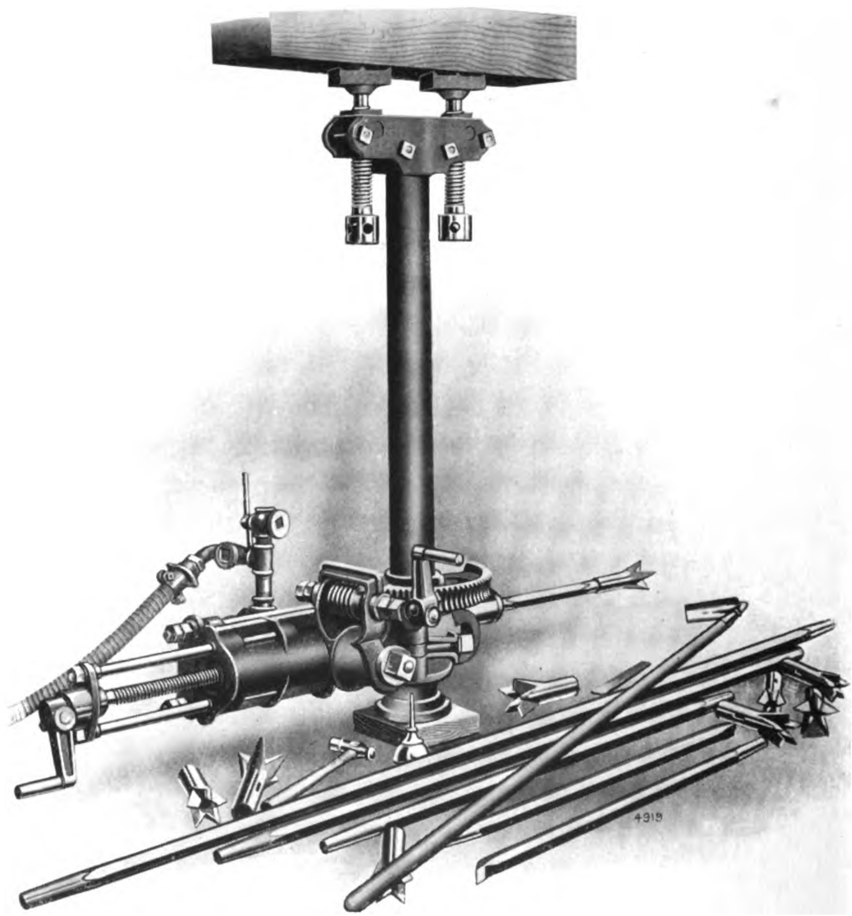


The Standard "Radialaxe" Mountings; Reading from Left to Right—"F-92" for Shearing; "F-92" for Undercutting; "G-48" for Shearing; "G-45" for Shearing.

tion of one of the Company's standard drill types. It has long through-bolts holding the front and back heads in place, and the "Sergeant" patent flat Cushion Spring. The "Sergeant" Release Rotation is used, similar to that of the regular Ingersoll-Rand rock drill. The piston rod, instead of having a chuck of the ordinary type, ends in a taper fitting an extension which also receives the steels. This arrangement dispenses with a split front head. When a seam or pocket is encountered the piston is cushioned on the forward stroke by a special cushion valve which entraps and compresses a portion of the air when the steel shoots forward beyond normal stroke. The valve movement is of the "Sergeant 92" type, having a means by which wear and consequent leakage past the valve can be compensated by proper adjustment of regulating screws. This is a most valuable feature, permitting the valve action and the consequent operation of the machine to be maintained at a point of maximum effectiveness.

The Mounting

The primary support is a single or double screw column which can be furnished in various lengths from two feet upward. With this column a special style of mounting is supplied which carries the "Radialaxe" machine or drill proper. A safety clamp or collar on the column below the mounting permits the latter to be swung to any position without sliding down. A worm and sector provides for swinging the "Radialaxe" back and forth in a plane, by means of a crank. The guide shell of the "Radialaxe" is similar to that of the ordinary rock drill and carries a feed screw, standards and a feed crank. It rests in a cone cup and is tightened or released by a bolt, instead of being rigidly connected to the mounting. This permits subdivision of weight in moving or setting up, and makes easier the handling of the machine. The worm sector is of large diameter and the worm of small pitch, making the swinging of the machinery very easy on the operator. The main trunnion, which is exposed to the full shock of operation, is of large diameter and length, and shows none of the wear which would result in lost motion, an unsteady mounting and difficult cutting. By means of the crank on the mounting the cutter is swung radially at right angles to its trunnion. By means of the feed



Standard "F-92" "Radialaxe" on "F-92" Type Mounting Arranged for Undercutting.

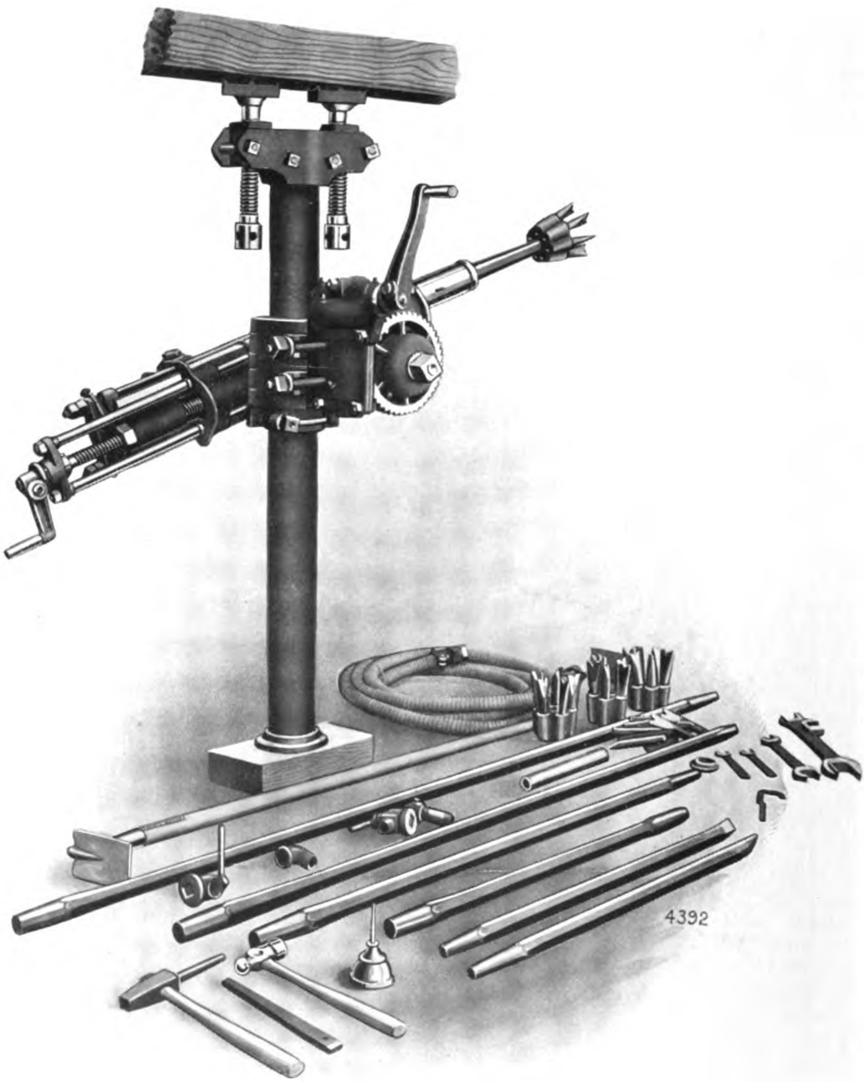
The Method of Operation

In operation the column is set up at right angles to the coal seam, 3½ or 4 feet from the face. A substantial wood block is placed under the footpiece and another on top of the column. The jack screw is then screwed home as tightly as possible, the screw end of the column usually being at the top.

Undercutting

In undercutting the column is placed at a distance of 6 to 6½ feet from the rib, the cut usually being started at the middle of the face. The "Radialaxe" is swung back and forth by means of its swinging crank. With the steel at the end of its swing, the feed screw is given two or three forward turns and the "Radialaxe" swung to the other extremity of its arc. Here the machine is again advanced by two or three turns of the feed crank and swung back again. This is repeated until the limit of feed has been reached, when a longer extension is inserted and the process continued until the maximum depth at center of swing has been made.

Undercutting an Entry with the "Radialaxe."



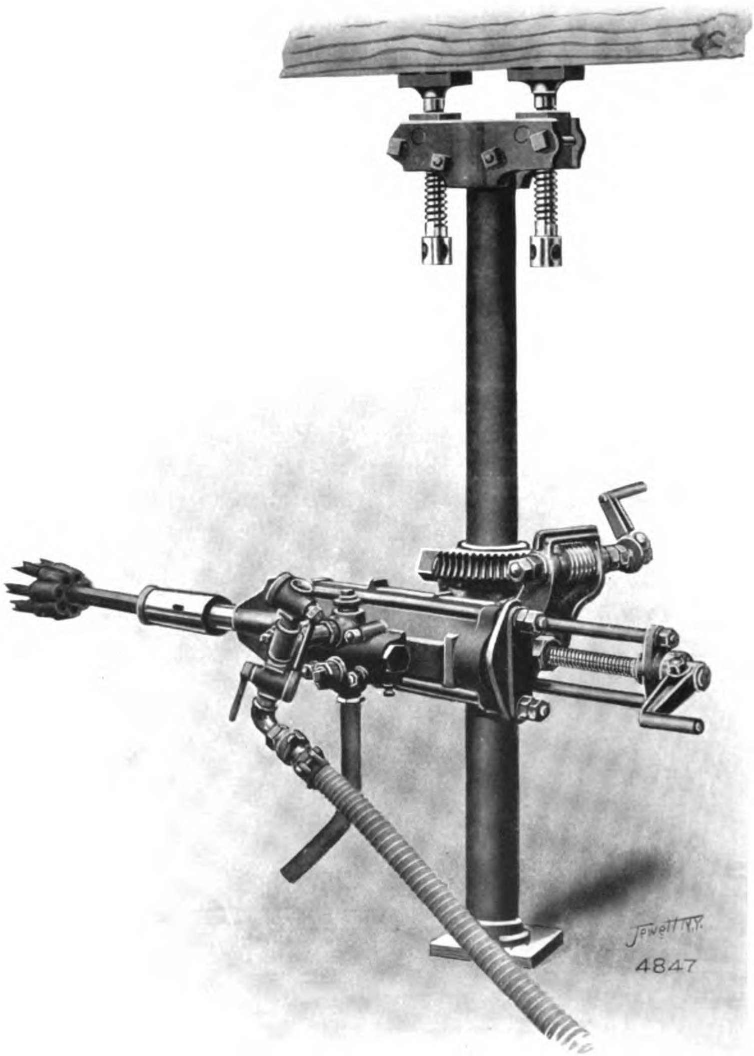
Standard "F-92" "Radialaxe" on "G-48" Type Shearing Mounting.

When the last steel has been used, it is evident that there will remain a portion of coal at the extremities of the arc still to be cut out in order to give a square undercut. This is worked out by swinging the "Radialaxe" back and forth through a small arc, feeding the steel forward until the end is squared up. The maximum swing of the "Radialaxe" is about six feet either side of its column, giving an undercut from one setting approximately seven feet in width and eight feet in depth, with a height at the back of about 2½ inches. The machine can readily be placed in such a position as to in no way interfere with the safe placing of props or timbers.

Shearing

In shearing, the column is mounted about ten inches from the line in which the cut is to be made. The safety clamp is mounted in such a position on the column that the center line of the "Radialaxe" cutter is about opposite the middle of the seam. The method of operation in this case is the same as described for undercutting, except that the machine swings in a vertical plane instead of horizontally. The radius of action in shearing is about the same as that in undercutting.

Shearing an Entry with the "Radialaxe."



Standard "F-92" "Radialaxe" on "F-92" Mounting Arranged for Cutting out Bands or Mining in the Middle of the Seam.

Removing Bands and Mining in the Seam

For removing clay or slate bands in the vein, or mining in the middle of the seam, the "Radialaxe" is mounted on its column so that its bit comes in a horizontal position on a level with the line of work. A cut is made in the band to the maximum depth and the cuttings are removed with the scraper.

In Regular Rock Drill Work

When used as a rock drill no change is required in the arrangement, the only point being that the radial swinging mechanism is not called into play, and the bit strikes in the same line continuously. When working in rock it is of course necessary to substitute a rock drill steel for the cutting bit of the "Radialaxe." The steel in this case must have a taper shank to fit the extension bushing.

Sizes and Capacities

The "Radialaxe" is furnished in three different sizes designated as the "C-92," "E-92," and "F-92." The "C-92" is used only with the regular "92" mounting adapted for shearing or undercutting. The "E-92" and "F-92" can be used with either the regular "92" mounting, the "48" or the "45" mounting. Complete specifications of these different machines, together with other important data as to sizes, weights, capacities, etc., are listed in the table on page 20.

"Radialaxe" Removing a Dirty Band Near the Top of the Seam.

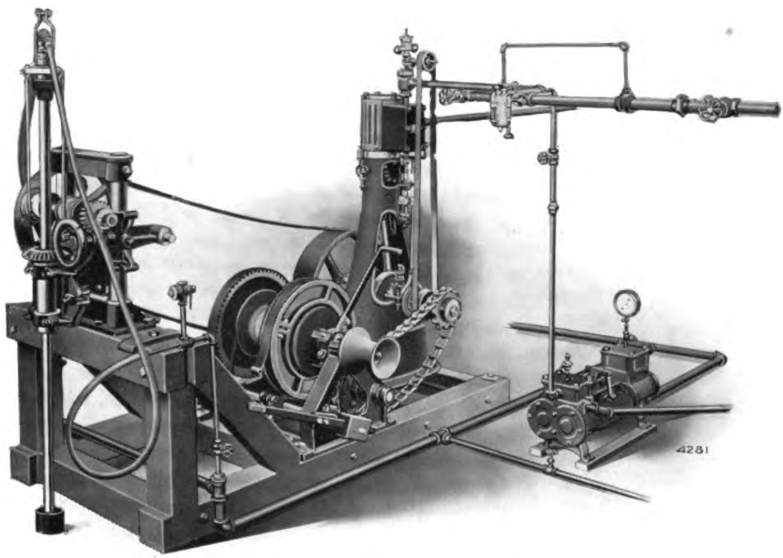
Descriptive Table of "Radialaxe" Coal Cutters.

	Outfit for Shearing and Undercutting 24" Feed			Outfit for Shearing and Undercutting 18" Feed		"48" Outfit for Shearing only 18" Feed		"45" Outfit for Shearing only 18" Feed		Outfit for Undercutting only 24" Feed	
Symbol indicating size and type	**C-92**	**E-92**	**F-92**	**E-92**	**F-92**	**E-92-48**	**F-92-48**	**E-92-45**	**F-92-45**	**E-92**	**F-92**
Diameter of Cylinder . . . in.	2¾	3¼	3½	3¼	3½	3¼	3½	3¼	3½	3¼	3½
Length of Drill from end of crank to end of chuck (closed) . . . ft. in.	3–9"	3 11½"	4–0"	3–11½"	4–0"	3–11½"	4 0"	3–11½"	4–0"	3–11½"	4–0"
Depth of cut drilled without change of steel . . . in.	24	24	24	18	18	18	18	18	18	24	24
Diameter of supply inlet (standard pipe) in.	1	1	1	1	1	1	1	1	1	1	1
Approximate number of strokes per minute with 80 lbs. pressure at drill. . . .	350	350	350	350	350	350	350	350	350	350	350
Depth to which each machine will cut . ft.	8–0	8–0	8–0	7–6	7–6	7–6	7–6	7–6	7–6	8–0	8–0
Style of mounting . . .	F-92	F-92	F-92	F-92	F-92	G-48	G-48	G-45	G-45	F-92	F-92
Style of bit . . .	Solid	Solid	Solid	Fishtail	Fishtail	Fishtail	Fishtail	Fishtail	Fishtail	Fishtail	Fishtail
NET WEIGHTS											
Drill and shell . . . lbs.	215	250	262	250	262	250	262	250	267	250	262
Mounting . . . lbs.	136	136	136	136	136	155	155	175	175	193	193
S. S. column 6 ft. long . . . lbs.	130	130	130	130	130	170	170	210	210	130	130
D.S. column 6 ft. long . . . lbs.	150	150	150	150	150	176	176	254	254	150	150
Extension steels, (F-92), one set (4) to 8 ft. . . . lbs.	89	89	89	116	116	116	116	116	116	116	116
Hose, 50 ft. length, with couplings. . lbs.	45	45	45	45	45	45	45	45	45	45	45
TELEGRAPH NAMES	Kaffekanne	Kaffesatz	Kaftan	Kahlnessel	Kaikeya	Kaisaniden	Kaiserhut	Kaiserthum	Kakaralli	Kakodyle	Kaktusform

DAVIS
"CALYX DIAMONDLESS" CORE DRILLS

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 9001 March, 1910



A Class "F-1" Steam Driven "Calyx" Drill Outfit, with Drill, Engine, Hoist and Pump

THE function of the core drill is the determination, by means of cores or cylinders extracted from an annular hole, of the character, order, thickness and extent of materials beneath the earth's surface. Its field is that of contracting, stone quarrying, and coal or metal mining. In work of this character the core drill has been developed to a state of reliability of record which has placed it in the forefront among all methods of securing subterranean data with accuracy and with the minimum of cost.

Two "systems" of core drilling find practical application today: The "diamond" core drill, using black diamonds or carbons set in its bit; and the "diamondless" drill, which uses either a steel cutter or a bit employing chilled shot or crushed steel as a cutting agent. Without drawing finer distinctions between these two systems, it may be said that the "diamondless" core drill will do practically all that can be accomplished with the "diamond" drill. More than this, it will extract cores of so large a size that the cost of carbons for a "diamond" drill of equal capacity would be prohibitive. Moreover, the cost of core drilling, per foot of hole and per foot of useful core secured, is less with the "diamondless" drill than with the "diamond" drill for a given size of core.

A Class "F-1" "Calyx" Outfit Making Bridge Soundings for the C.B. & Q. R.R. at the Mouth of the Ohio River

In Contract Work

As engineering enterprises grow in magnitude — dams, canal locks, bridges, buildings, etc. — and the capital invested increases, more and more attention is being given to securing permanent and absolutely safe earth supports for these structures. No surmise as to underlying materials can be hazarded. The contractor must *know*. Formerly the method employed was the sinking of exploration shafts. But these are costly — their cost increasing out of all

"Calyx" Core Drill Question Sheet

The regular outfits for various types and sizes of "Calyx" Drills are given in separate pamphlets, but owing to the diversity of requirements for core drill operation, the Ingersoll-Rand Company prefers to furnish each of its customers a detailed and complete specification in each case. This is considered to be an advantage to the Company and to its customers, and in order that such specifications may be made intelligently, customers are requested to use this blank when requesting a quotation.

1. Locality and facilities of transport? (This is important as bearing upon the selection of the proper machine, and the amount of extra supplies advisable, such as core barrels, bits, shot, etc.)

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2. Object of drilling (mineral prospecting, gold, silver, lead, tin, copper, iron, coal, salt, mica, etc.; water wells; contract soundings)?

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3. Deepest hole to be bored and the total approximate number of feet to be drilled?

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4. Dimension of hole and core wanted?

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5. Character of rock, so far as known?

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Is it likely to be solid or broken?

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6. Is work to be done from the surface or underground?

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7. If underground, give full particulars as to depth from surface, size of entry or shaft, available head room, etc.

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8. If work is from the surface, state as nearly as possible the depth of surface material (if any) overlying the rock.

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9. Is the surface material gravel and boulders, or sand and loam? (It is important to have as much information on this point as possible.)

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10. Is there a supply of water available (only a small amount is necessary)?

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If gravity supply is not available, state distance and lift.

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11. Is fuel, wood or coal available? If so, steam power is always recommended.

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12. When not governed by local conditions, choice of power is recommended in the following order: steam, compressed air, gasoline engine, electric motor, horse power and hand power.

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The Company appreciates that it is not always possible to give positive data on all of the above points, but these items will suggest the line of information required; and the receipt of this information will enable the Company to quote on a machine and equipment best suited for the work.

Name..

Street..

City.................................. *State*..................................

INGERSOLL-RAND COMPANY
11 Broadway, New York

proportion to their depth — and it was out of the question to thoroughly explore any extended area. Modern methods now use the core drill, a number of holes sufficiently close together to assure accuracy of information being sunk through all overlying materials to a suitably rigid stratum from which building may begin. The data thus secured not only afford a true basis of estimate, but also render possible the purchase of the most suitable surface equipment for handling the work. Such accurate information may mean the saving of thousands of dollars.

3520

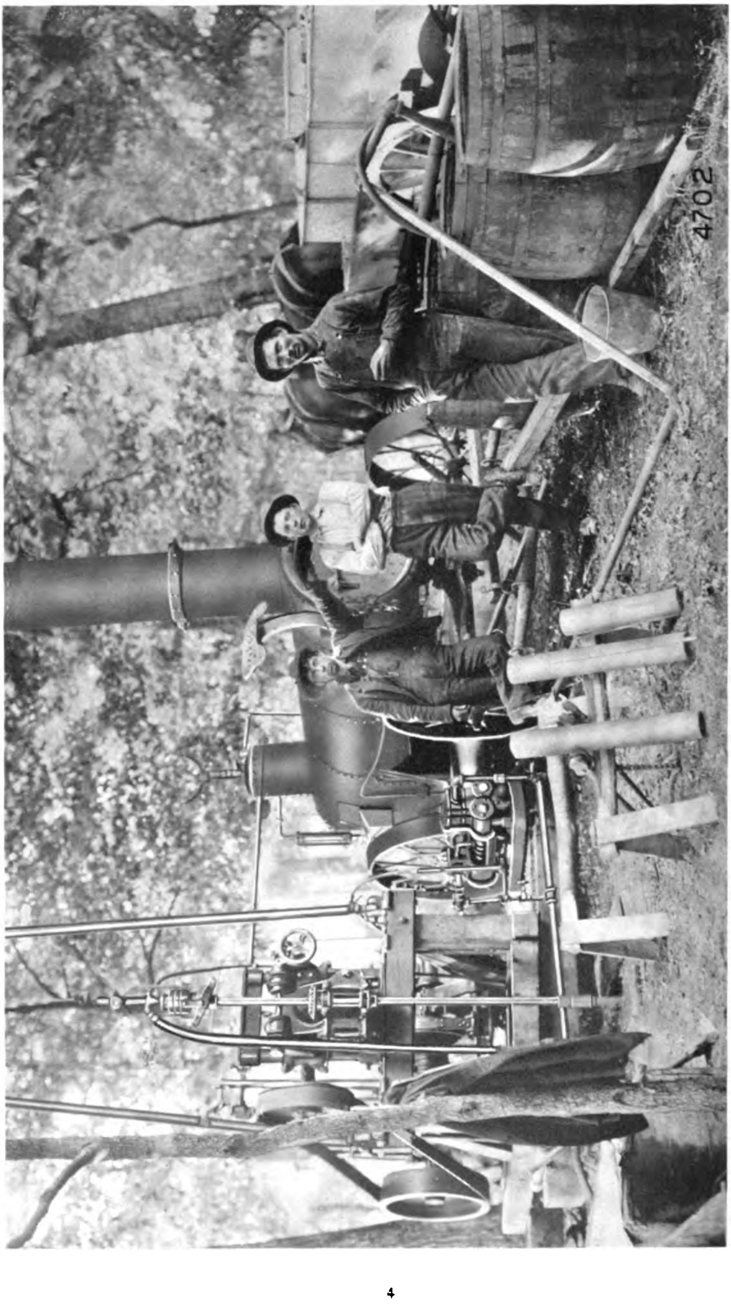
An 8-inch "Calyx" Core which penetrated Brick and Two 2-inch Steel Plates

For canal or tunnel developments projected, a series of core drill borings along the contemplated line removes every element of chance or hazard from the undertaking and places it at once upon the solid foundation of certain knowledge, with a practical certainty of satisfactory results. The experienced contractor knows, without further discussion, what this information means to him. An important feature in these advance investigations is that, while entirely accurate, they shall be secured at the minimum cost both for equipment and operation.

In Stone Quarrying

When a stone property is to be developed, the core drill will reveal the depth, extent and value of the stone deposit almost without scratching the surface. A series of holes, arranged in some systematic order, can be carried to any depth desired, and the cores, as extracted, show exactly the character, dip, thickness, color, etc., of the stone which is later to be a marketable product.

In operating quarries, the same means carried in advance of operations shows just the conditions to be encountered and makes possible the most intelligent and economical application of the quarrying processes.



A Class "F-1" "Calyx" Outfit at Work at Bedford, Indiana, for the Southern Indiana R.R. Co.

In Coal and Metal Mining

It is perhaps in the mining field that the core drill is afforded the widest scope of usefulness and of value as a time, labor and money saver. In no branch of industry can costly mistakes be so easily made as in mining. A mining claim or a coal property is absolutely an unknown quantity. Surrounded it may be by known valuable holdings. But a "fault" or a "squeeze" may cut off the value-bearing strata from the section in question; and unless this can be determined in advance, thousands of dollars may be expended in machine equipment, shafts, and underground workings, only to find a barren property.

The old methods used a prospect shaft. It was costly to begin with and might "prove up" no value. If values were found, it probably was found to encounter the vein at the wrong point for most economical development and operation. It was a small shaft and must be enlarged to become useful for mining. It was a gamble, with all the chances against the prospector.

Today the core drill wipes out all uncertainty. Systematically spaced core holes driven to the requisite depth show whether values exist or not; how deep they are to be found; what materials must be penetrated in reaching them; the thickness and extent of the vein; the "dip" or angle at which it lies; and finally, actual samples of the pay material, showing its value.

Prospecting for Coal in Colorado with a "Calyx" Drill Outfit

Class "F-1" "Calyx" Drill on the Property of the Southern State Portland Cement Co., Rockmart, Ga.

With this data, if development is found to be justified, the best point for sinking the shaft can be determined, so that all tramming will not be up-hill and all water will not drain away from the opening. The best surface equipment can be selected. The entire underground layout can be planned with more than a fair degree of accuracy and a systematic scheme of operation laid out in advance. To sum up, the use of the core drill makes mining a business proposition.

Where stock is to be sold to develop a mining property, exploration with a core drill, by demonstrating the existence of ore bodies underground, will make easy the disposal of the stock at a good price.

"Diamond" Core Drills

When the core drill was first devised and brought to a practical development, black diamonds were to be had at a price of from $3.00 to $5.00 per carat. Had the price of carbons remained at this figure, the more modern substitutes for the diamond drill would never have been necessary. But the increasing use of the core drill, creating an increased demand for "black diamonds," produced a steady advance in their price until today the figures run from $65.00 to $90.00 per carat, depending upon the size and quality of the stones. The "diamondless" core drill, therefore, is the result of commercial conditions demanding some method of core drilling not calling for these costly carbons.

The Ingersoll-Rand Company has no desire to create any misconception about the diamond drill. This machine, within its proper limits (which are fully acknowledged even by its builders), is a successful and satisfactory core drill. At the same time it is well to clearly understand these limitations.

The cost of a diamond bit alone is always a very large part of the total cost of a diamond drill oufit; and when the machine is intended for coring large holes, the cost of the bit frequently equals, and sometimes exceeds, the cost of all the rest of the oufit. These considerations limit the size of the cores which can be extracted with the diamond drill to those of small diameter, not always large enough for modern requirements.

The wear on the carbons is a variable quantity, depending upon the nature of the rock being bored. But in some materials this wear is very rapid. This means the frequent resetting, if not the

actual renewal, of the diamonds in the bit, requiring not only an additional expenditure for carbons, but also the services of an expert diamond setter. Frequently a duplicate equipment of diamond bits is purchased, so that work may progress without interruption while the diamonds are being renewed or reset in a worn bit. The proper setting of the carbons in a diamond bit is of the most vital importance. The loss of one or two imperfectly bedded stones is a serious matter. While if the stones are incorrectly placed as to clearance, etc., the cutting capacity is greatly reduced. The wages of an expert diamond setter are usually, therefore, to be added to the labor charge against the diamond drill.

8-inch Cores from a Depth of 700 Feet, taken with a "Calyx" Drill at White Plains, N.Y.

It is not unusual to "lose a bit" in core drilling. Sometimes it can be recovered, sometimes not. A diamond bit lost entirely means a large sum of money lost — not only the cost of the carbons, but also the cost of the hole so far as it has progressed.

The thing which is decisively in favor of the diamond drill, as against all other core drills, is its ability to bore a hole at any angle whatever, up or down. This advantage finds its chief value in mine prospecting underground, where it is desired to explore a vein at any angle, in advance of development.

"Diamondless" Core Drills

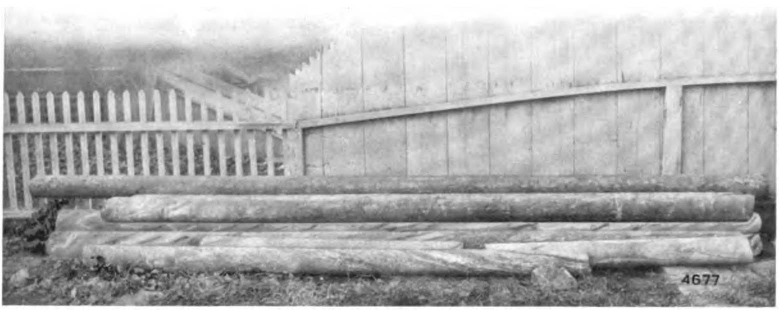
The "diamondless" core drill, as represented in the Ingersoll-Rand "Calyx" Core Drill, has been the result of a demand for a successful core drill fairly comparable, in every way possible, with the diamond drill, but free from the excessive charge for diamonds. It may be remarked at this point that the Ingersoll-Rand Company is today the only manufacturer of core drills offering a

"Calyx" Drill in the Mine of the Stone Canyon Coal Co., California

consistent line of machines for accomplishing a given purpose by a given means. Its line is distinctly "diamondless" in every detail; and the effort of years applied to this line has produced the present improved machines which are "standard" in their class, as are the Company's other products.

The "Calyx" Core Drill is described in detail later. But at this point it will be compared, item by item, with the diamond drill as set forth in the preceding section.

The "Calyx" Diamondless Core Drill is primarily a shot drill, using steel cutters only in soft materials, and chilled shot or crushed



5-inch Granite Cores Taken from a Depth of 1000 Feet in Drilling a Well with a Class "BF-1" "Calyx" Outfit in Westchester Co., N.Y.

steel with a suitable bit in the hardest and, in fact, in the great majority of substances. At the outset, therefore, it must be seen that the cost of bits for a "Calyx" outfit is to the cost of diamond bits as the cost of shot or crushed steel at about four cents per pound is to the cost of black diamonds. As a matter of fact, the bit equipment of the "Calyx" Drill is one of the smallest items of cost in the entire outfit. This condition at once removes all limits from the size of core which can be extracted, *at a commercial rate*, with the "Calyx" Drill. Standard machines provide for cores from $1\frac{5}{8}$ to 20 inches in diameter, and still larger sizes have been handled by special machines.

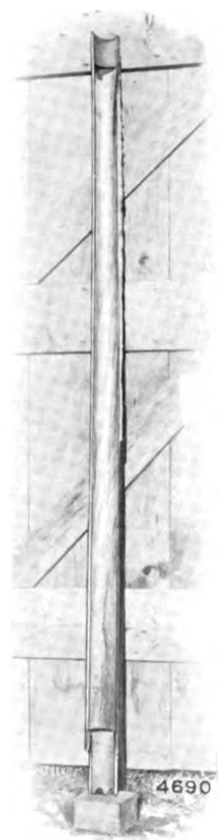
The advantage of this large core capacity is readily seen. While the small core to which the diamond drill is limited may serve

very well in hard, homogeneous materials, it is utterly useless in soft, broken, friable materials which will not hold together in a perfect core. As reliability of record is a prime requisite in core drilling, the great advantage of the "Calyx" Drill in this respect is at once apparent; for with this machine, perfect cores are the rule, rather than the exception, in all kinds of materials.

The relative cost of wear of bit, as between the "Calyx" Drill and the diamond drill, is again in favor of the former in the proportion of cost of shot or crushed steel to cost of black diamonds, for there is little wear on the bit itself. Easy drilling for the diamond drill is easy drilling for the "Calyx" Drill; hard drilling for one machine is hard for the other. So that this proportion of bit cost in the two cases remains the same whatever the material being cored. A duplicate set of "Calyx" bits is a very small item, and these bits can be taken care of by an average mechanic, as against the high-priced diamond setter which the diamond drill demands.

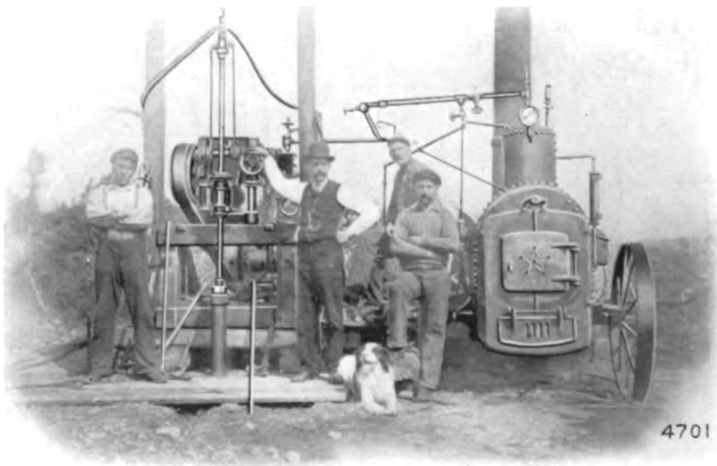
The "Calyx" Drill may lose a bit in the hole, and this bit may or may not be recovered. But in the latter case the hole is not lost. For a feature of the "Calyx" Drill is that a new bit will simply cut through a "lost" bit, and continue the hole with practically no interruption. It is next to impossible to "lose a hole" with the "Calyx" Drill.

The "Calyx" Drill with shot bit is limited in its application to holes not more than 45 degrees from the vertical. This limit is



Part of a Core Barrel and String of Tools Drilled out by a "Calyx" Shot Bit after they had been Lost in the Hole

fixed by the tendency of the shot to run to the lower side of the hole. The "Calyx" Drill, however, in spite of this condition, is adapted to by far the greater amount of core drill work, for the cases where this angle must be exceeded are comparatively rare. As already stated, they are found almost exclusively in underground exploration. But the vast field of surface work, and drilling close to the vertical, still lies open to the "Calyx" Drill, with all its advantages.



Prospecting Coal Land in Newfoundland, with a Class "F-1" "Calyx" Drill Outfit

Core Drilling Costs

Other things being equal, that core drill must be considered the best commercial proposition which extracts cores at the least cost per foot. The cost of core drilling involves four items, all of which must be considered in making any fair comparison. These are: interest and depreciation on equipment; maintenance and repairs; power charge; and labor.

Interest and depreciation are a certain percentage of first cost of equipment. The larger the investment, the greater the charge on this account per foot of hole cored. While the diamond drill and the "Calyx" Drill are about on a par, so far as the first cost of

machine equipment alone is concerned, to this must be added, in the case of the diamond drill, the cost of the expensive carbons. The "Calyx" Drill, therefore, has this great advantage over the other type, in this first item of drilling cost. The advantage of the "Calyx" Drill grows larger and larger as the size of the hole bored increases. Based on cost of complete equipment for cores of a given size, the "Calyx" Drill is undoubtedly lower in first cost and therefore cheaper in interest and depreciation charge.

A 5-inch Core of Soft Coal Taken with a "Calyx" Outfit in Prospecting in Colorado

Under the item of maintenance and repairs must be charged all the wear-and-tear, all the up-keep charge, on the equipment. It has already been pointed out that there is almost no comparison in the cost of bit wear and replacement, as between the "Calyx" Drill and the diamond drill. Repairs also are likely to be much more with the latter machine than with the former, because the diamond drill is as a rule more complicated, and because, in the very nature of things, the pressure required on its bit results in heavy stresses on the machine. In the "Calyx" Drill, on the contrary, only a slight pressure is required for the first hundred feet or so, the weight of the rods thereafter furnishing all the pressure necessary on the bit.

In the matter of power and labor costs there is perhaps little advantage in favor of either type of drill — unless the wages of an expert diamond setter be figured in labor cost against the diamond drill, in which case the advantage at once swings to the side of the "Calyx" Drill.

Operating conditions vary to such an extent that it is impossible to present figures of actual cost comparisons under exactly parallel circumstances. But an average of results over a long period of observation and experience shows that the "Calyx" Drill does its work at a cost from 30 to 50 per cent less than the diamond drill.

In one instance, in West Virginia, very unsatisfactory progress had been made with a diamond drill, at a cost of $2.00 to $2.25 per foot. The substitution of a "Calyx" Drill gave entire satisfaction, produced a larger core, and brought the cost down to $1.00 to $1.15 per foot. The rate of drilling per day was 20 feet in hard sandstone and 10 to 15 feet in a very hard quartz conglomerate.

A feature worthy of special notice in this connection is the fact that, with the "Calyx" Drill, cores 4 or 5 inches in diameter can be extracted as cheaply as cores 1 or 2 inches in diameter, and the rate of progress with these large cores is as good as, and sometimes even better than, the rate with smaller cores.

Moreover, holes of different diameter can be drilled with the same machine without special features, the only extra equipment being a core barrel, "calyx" and cutter or bit for each size of hole. The diamond drill, on the contrary, requires not only an entirely different set of tools, but another set of drill rods as well. This gives a wide range of adaptability to various classes of work, with a single "Calyx" machine.

5-inch Core of West Virginia Soft Coal, Made with a "Calyx" Drill

Reliability and Accuracy of Record

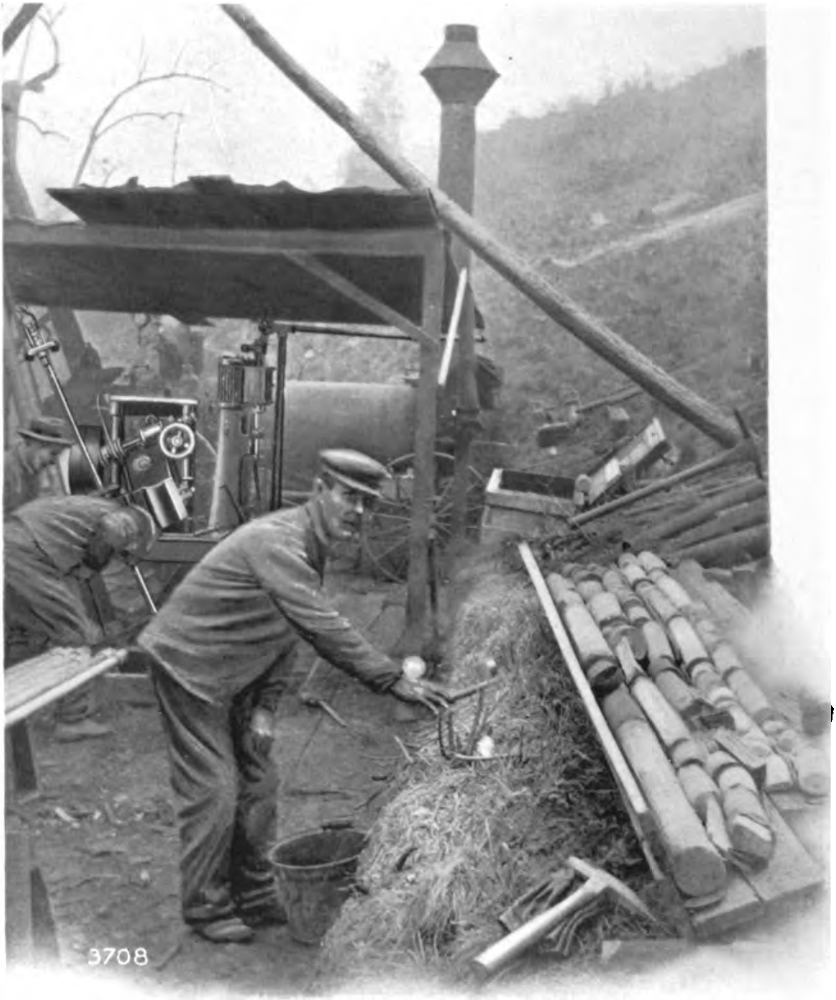
A core, to be of value as a record, must be an exact section of the material from which it is taken. It must not be broken, or ground up, or compacted, but must be in its original condition. The successful core drill, therefore, must extract a core without injury or loss of character. While a small core of hard, tough material will hold together, by far the greater percentage of cores must come from substances demanding a relatively large cross-section to remain intact. Here the "Calyx" Drill has its great advantage. Cores of any diameter can be extracted without running into prohibitive cost of bits with this machine.

3207

A Core From a 20-inch Steel I-Beam Made with the "Calyx" Drill, Using a Shot Bit

Cutting Capacity

The "Calyx" Drill will cut through any material yet encountered. In this respect it has all the capacity of the diamond drill, beside all the advantages already enumerated. Among the softer materials which have been cored with this drill are clay, shale, coal, slate, sandstone, limestone and marble, of almost every degree of hardness. Among the harder rocks which it has successfully handled are granite, taconite, jasper and corundum rock — the latter probably the hardest substance ever cored. In foundation exploration and contract work, the "Calyx" Drill has successfully encountered and penetrated cast steel, rolled steel and cast iron, in the form of old car wheels, structural steel shapes, sheet steel, old car couplings, etc. The successful record of this drill justifies the claim that *it will core any substance at a paying rate.*



Prospecting for Coal in Monterey County, California, with a "Calyx" Drill Outfit.

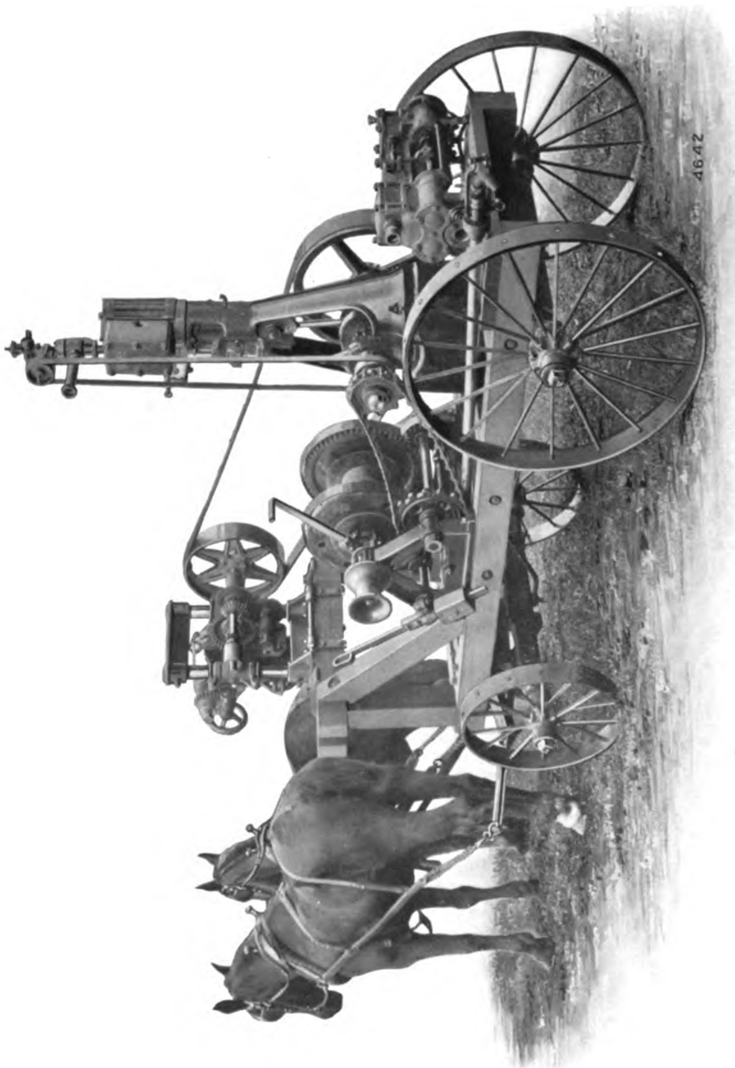
The "Calyx" Diamondless Core Drill

A complete "Calyx" Core Drill outfit includes, beside the surface equipment, four essential elements: the cutter or bit, which penetrates the materials encountered and which may be either of the Davis toothed pattern or designed for the use of chilled shot; the core barrel, which is a tube carrying the bit and of the same outside diameter as the main body of the latter; the drill rods, screwed into the reducing plug at the upper end of the core barrel and extending thence to the driving mechanism at the surface; and the "calyx" which is a tube of the same diameter as the core barrel, screwed to the reducing plug and extending upward around the drill rods.

Three Standard Sizes of Drill Rods and Couplings for the "Calyx" Drill

The Principle of Operation

Power applied to the drill rods at the surface rotates the latter with the "calyx," core barrel, and bit or cutter. Water is pumped through the hollow drill rods and into the core barrel. As the bit rotates, it cuts a circular groove in the material under it. The water passes from the core barrel, under the bit and up through the annular space left around the core barrel by the clearance on the bit, the stream carrying with it the cuttings. This water rises at high velocity until the top of the "calyx" is reached, where its velocity is greatly reduced because of the larger passage afforded around the drill rods. The heavier cuttings carried by the water therefore have a chance to settle at this point, falling into the



A Portable Class "F-1" Steam Driven "Calyx" Outfit

"calyx" on top of the core barrel plug. As the bit penetrates, a cylinder or core of the material drilled rises through the hollow bit into the core barrel.

When the core barrel has been filled for nearly its full length, the core is broken off, and the core barrel with its contained core, the bit and the "calyx" are hoisted to the surface. Evidently this core, if it is intact (as it is almost invariably with the "Calyx" Drill), is an exact section of the strata penetrated by the bit. The cuttings, moreover, are deposited in the "calyx" in the reverse order of their penetration, thus constituting a second, or duplicate, record of the materials passed through. The core and "calyx" cuttings are removed, a length of drill rod attached (if necessary), the string of tools lowered in the hole, and drilling resumed.

The great advantage of the "calyx," quite aside from the value of its duplicate record, is that the bit or cutter always has a clean surface to work upon and is not impeded in its action by an accumulation of mud and cuttings around it. The "sludge" which would otherwise settle around the bit and core barrel is caught in the "calyx." The hole being always kept clear of cuttings, it is impossible to jam or stick the bit, and a record of thousands of holes cored with this drill does not show one hole lost through the jamming of the bit.

The flow of water is adjusted, with a little experience, to a rate such that the cuttings are carried away freely while the shot is not lifted. The shot thus rolls around on a clean-washed surface, and the cutting speed is the maximum.

Prospecting in Colorado with the "Calyx" Drill; Removing the Core from the Core Barrel

4631

Without "Calyx" Holder

4630

With "Calyx" Holder

A String of Standard "Calyx" Drill Tools

Arrangement of Tools

The two illustrations on the opposite page show the two arrangements of tools used in the "Calyx" Drill in the hole. The cut on the left is a section of the arrangement for the smaller sizes, up to and including a 3-inch core barrel, taking a 2⅜-inch core. Referring to the letters in the section, the parts are as follows:

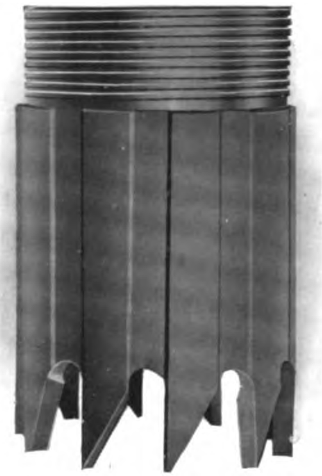
A — core barrel plug.
C — calyx.
D — core barrel.
E — matching coupling.
G — hollow drill rods.
H — shot bit.
L — chilled shot.

For drills using a larger than 3-inch core barrel, the arrangement is as shown in the right-hand illustration. Here a "calyx holder" is placed at the top of the "calyx," giving steadiness to the string of tools and preventing vibration of the drill rods in the "calyx." Again referring to the letters on the cut, the parts are as follows:

A — core barrel plug.
B — calyx.
D — core barrel.
F — hollow drill rods.
H — shot bit.
I — calyx holder.
J — calyx rod.
K — matching coupling.
L — chilled shot.

The Davis Cutter

The "Calyx" Drill employs the Davis cutter at the bottom of the core barrel in drilling in soft and moderately hard material. Probably its most frequent and practical application is in starting a hole, and in soundings through ordinary deposits. It is a cylinder of steel, with teeth forged from steel of a special composition. The Davis cutter is in reality a compound chisel, set for clearance inside and outside, working in a circular groove. It is easily sharpened, and, in materials for which it is adapted, cuts rapidly and freely. Experience has shown that, where properly used, the wear and tear on the

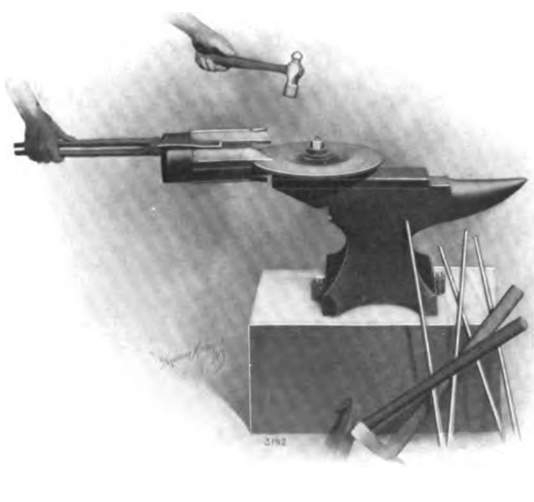


4744A

A Standard Davis Cutter as Used on the "Calyx" Drill

cutter amounts to but a small fraction of a cent per foot of core. While a very simple device, this cutter has shown itself capable of taking cores from harder rock than has ever been cut by any other steel tool.

It is to be noted that the Davis cutter does not *cut* the rock, but rather *chips* it away. The drill rods carrying the core barrel and cutter are revolved at proper speed, a continuous stream of water passing down the drill rods, through the cutter teeth, and up outside the core barrel. The weight of the drill rods and string of tools forces the teeth of the cutter into the rock. The cutter does not begin to act the moment rotation begins. On the contrary, the teeth having caught in the rock, the drill rods will be twisted in some degree before enough energy is



Sharpening a Davis Cutter on the Dressing Plate furnished with each Complete "Calyx" Outfit

stored up in their torsion to overcome the "bite" of the teeth in the rock. The moment, however, the stress in the rods overcomes the resistance under the cutter, fragments of rock are broken and hurled from before the teeth; the cutter springs forward; its teeth again "bite" the rock and the cutter stops. Meantime the drill rods continue to rotate, and the cutter breaks loose again and again, each time cutting deeper and deeper.

The operation of the Davis cutter finds its closest analogy in the action of the stone mason's chisel and hammer, which will cut even very hard rock. The Davis cutter simply delivers a succession of hammer-and-chisel blows on the rock beneath its teeth, and cuts it with surprising rapidity. The core or cylinder left untouched by the cutter teeth rises in the middle with perfect freedom because of the inside clearance left by the teeth. The outside clearance leaves the annular space around core barrel and "calyx" through which water and cuttings rise.

The Davis cutter used on the "Calyx" Drill makes rapid and satisfactory progress in such materials as clay, shale, slate, ordinary sandstone, etc. In these substances a penetration of three-quarters of an inch per revolution is not unusual. But when a certain degree of hardness is reached, the rate of progress becomes so slow as not to be economical. At this point the Davis cutter must be replaced by the shot bit, which has yet to reach its limit in the hardest substances yet encountered. The Davis cutter requires a slow speed, while shot drilling calls for a higher speed. "Calyx" Drills, therefore, are arranged to give these two speeds. While manufacturers of other core drills—diamond and otherwise—furnish steel cutters, their machines do not afford

4779

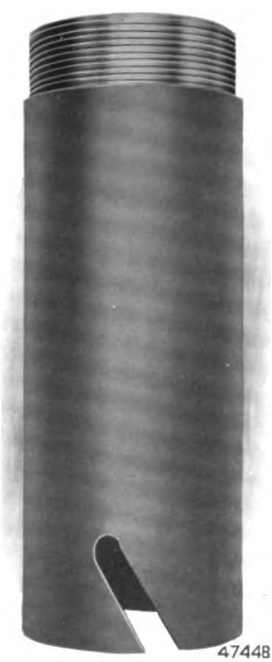
A String of "Calyx" Drill Tools with Davis Cutter, and Double Stand Pipe Penetrating Loose Material

the slow speed required with the latter and without which no steel cutter can be used with any degree of success.

The Shot Bit

Chilled shot is produced by atomizing molten iron or steel and suddenly chilling the small particles thus produced. The resulting material is so hard that it will scratch glass. The chilled metal varies from a powder so fine that it can be blown from the hand with a breath, up to particles as large as a duck shot. The largest may be three-eighths inch in diameter, but the average drilling size is about three thirty-seconds of an inch.

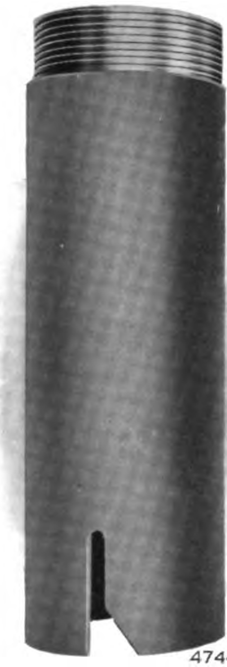
Chilled shot has been used for years for sawing and polishing stone, but its use for core drilling is of more recent date. Another material sometimes used is crushed steel, variously sold under such names as "diamondite," "abrasite," etc. While ordinarily it is inferior to chilled shot, and does not give such satisfactory results, yet for comparatively soft formations it is sometimes better than shot.



A "Calyx" Shot Bit with Diagonal Slot

The shot bit of the "Calyx" Drill is simply a smooth cylinder of steel, attached to the core barrel and rotated with the latter by the drill rods. A narrow slot is cut in one side of the bit. The chilled shot, fed from above, is rolled around between the bit and the rock, milling away the latter under the rotation and pressure. Of course the bit as well as the rock is worn away. But the rate of wear on the steel is much slower than on the rock and the bit is very inexpensively replaced. The design of the "Calyx" shot bit was the result of years of experiment, and in its present perfected form there is no known rock too hard to core at a commercial rate.

The method of shot drilling is itself very simple. The shot is fed into the



4744C

A "Calyx" Shot Bit with Square Slot

drill through the shot-feed, and the stream of water continuously flowing through the drill rods carries the shot to the bottom of the hole beneath the bit. The flow of water is so adjusted as not to lift the shot from the hole, while still carrying upward the cuttings and mud which are lighter than the shot.

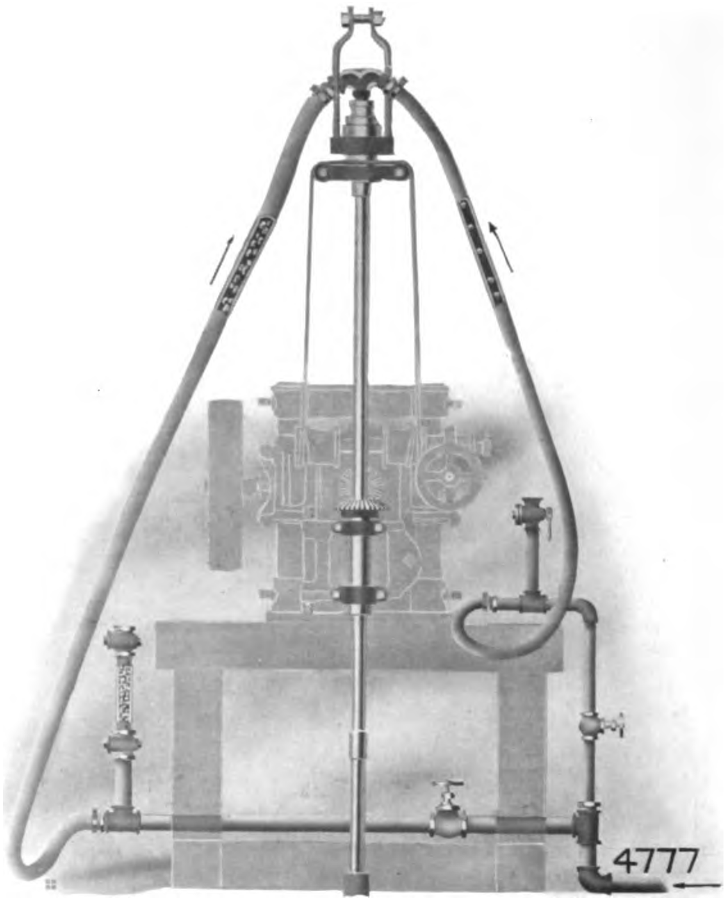
The amount of shot required varies with the nature of the material being drilled. Shale, slate, limestone and ordinary sandstone may require from one-quarter to three-quarters of a pound of shot per foot of hole. Very hard sandstone, granite, quartz conglomerate, porphyry, taconite and jasper require from one and a half to four pounds per foot.

Chilled shot is useless in materials so soft that the shot becomes bedded. But on the other hand nothing has yet been found hard enough to successfully withstand its action. A remarkable record was made in a Canadian corundum rock, which was drilled more rapidly and economically by the "Calyx" shot bit than by the diamond drill, though the latter had been used. A peculiarity of the shot bit is that, itself made of metal, it experiences no difficulty in cutting through other metals with the aid of the shot. Instances of this are illustrated on pages 3, 11 and 15.

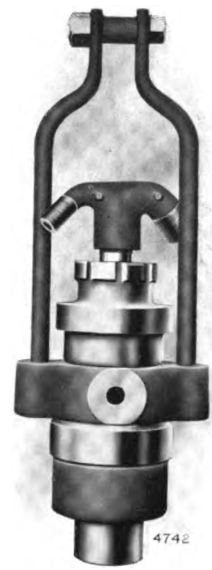
In most rocks, the shot automatically cuts the necessary clearance inside the bit, so that there is space between core and bit for the shot to pass to the bottom of the hole. Occasionally, however, a material is encountered which makes a core fitting very closely inside the bit. To permit the passage of the shot in such a case, two grooves of a size varying with the size of the bit are milled lengthwise inside the bit. Through these grooves the shot passes freely to the bottom of the bit, even past a close core.

The "Calyx" Shot Feed

The method of feeding the shot into the "Calyx" Drill is worthy of special note, as it is the only successful means yet devised for this operation. The water swivel at the top of the drill rods has two connections, the larger for the wash water and the smaller for feeding shot. Both are connected to the pump. A length of small hose connects the smaller opening on the water swivel to a tee, on the branch of which the shot feed is placed. The latter is a special valve, with a hopper at the top, from which the shot is fed



The Method of Feeding Shot and Grout to the "Calyx" Drill

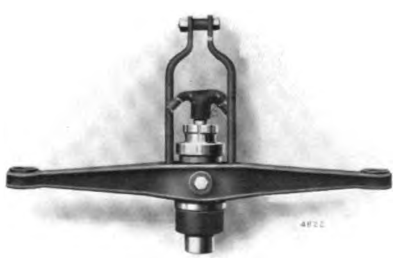


A "Calyx" Water Swivel or Hose Connection

slowly by means of a handle. This shot falls to the tee and is there caught in the water current and carried, a few at a time, up to the water swivel and into the drill rods, thence down to the bit. The rate of flow of water through the shot feed hose is so adjusted that the shot is carried through in a scattered condition — not in a mass.

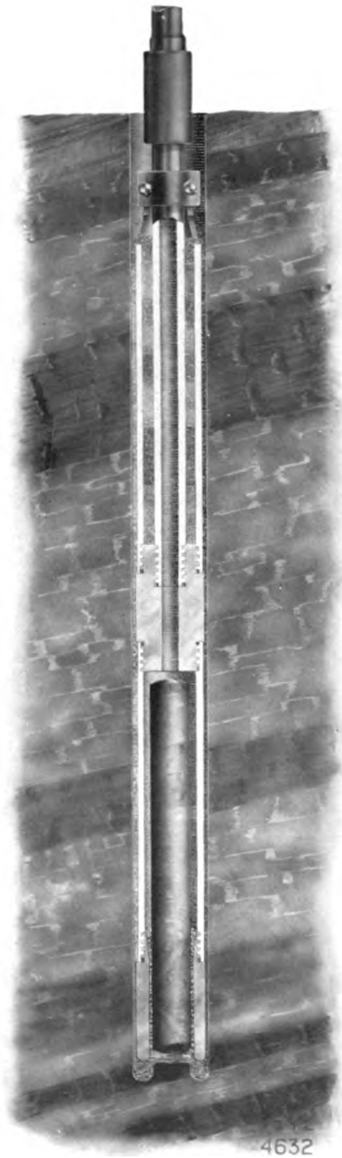
The disadvantages of other methods of feeding shot are many. Simply pouring it down the hole wastes a large percentage of shot, for only a small portion of it gets under the bit and the rest simply grinds the rods and core barrel. Shot cannot be fed into the regular wash pipe, for the flow of water normally used will not carry up the shot, and the speeding up of the pump to carry the shot creates a water pressure at the bit which will entirely wash away the shot from beneath it. Pouring shot into the drill rods at the top (aside from the danger of spilling chilled steel into the gears of the machine) delivers the shot in a mass which wedges between core and bit, breaking the core.

The "Calyx" shot feed is patented and cannot be had on other than the "Calyx" Drill.



A "Calyx" Water Swivel with Evener Yoke for Pressure Device

The two illustrations on this page show the water swivel, or hose connection, at the top of the drill rods, which permits the rotation of the latter without twisting the hose. The lower figure shows the yoke attachment used to apply pressure on the bit when starting the hole.



The Method of Grouting and Breaking the Core in the "Calyx" Drill

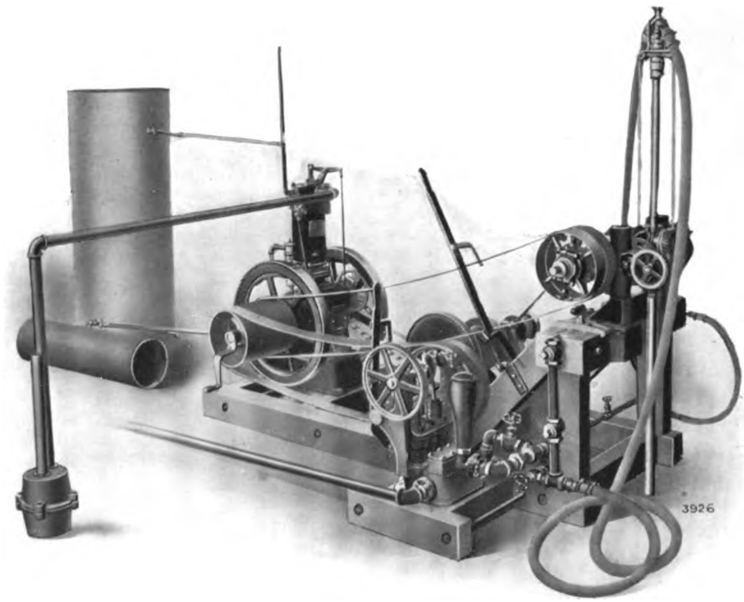
Extracting the Core

Having briefly described the operation of core drilling with the "Calyx" Drill, the next process in natural order is the breaking and extracting of the core. Drilling is continued until the core has filled the core barrel to within a few inches of the core barrel plug. Rotation is then stopped and the flow of water increased to wash out the hole around the bit and core barrel. A quantity of "grout" (small gravel of irregular shape) is then introduced through the "grout feed," and pumped to the bottom of the hole, the pump being speeded up to increase the water pressure for this purpose. This grout lodges inside the bit, between the core and the inner walls of the bit, which is of smaller inside diameter than the core barrel. Here it is wedged by the water pressure, around the core, inside the bit or cutter. The drill is now started and the rods given a few sharp twists, which compacts the grout around the core and breaks the core, usually inside the bit or cutter. The drill rods and the string of tools with the contained core are lifted to the surface. The grout is loosened by a few hammer blows on the core barrel, and the core taken out. If the material has been free from seams, a solid core the length of the core barrel will be found. If not, a series of cores separated by natural cleavage lines will be the result — but a true record, nevertheless. The standard core barrel, when full, extracts a core 12 feet long. Special core barrels can be made up to any length desired, either in a single tube or by using several core barrels joined.

Prospecting for Coal with the "Calyx" Drill at Oak Creek, Colorado

The Surface Equipment

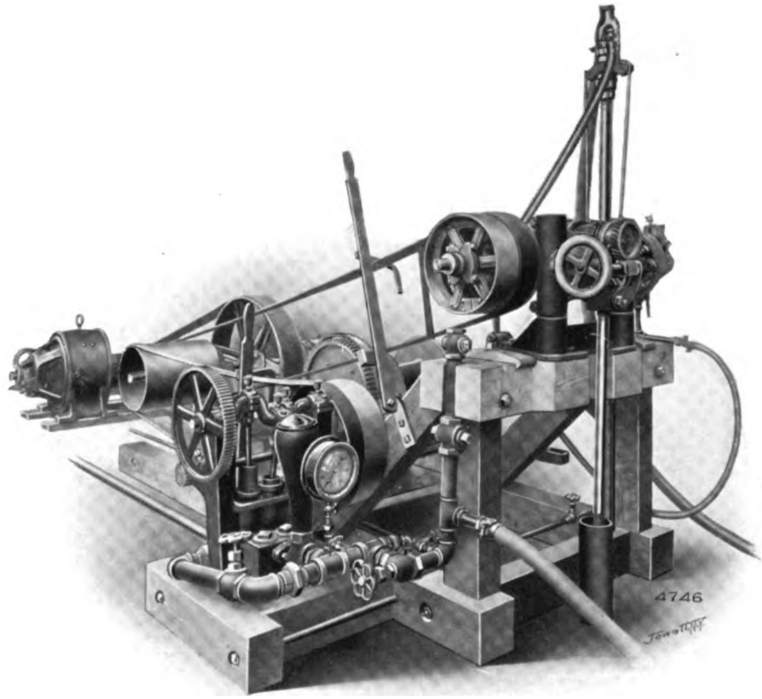
"Calyx" Core Drills are built in several styles and sizes adapted to various sources of power: hand, horse power, gasoline engine, steam engine, or any independent prime mover — as described in the separate pamphlets on the individual machines listed later. The surface equipment includes the drilling machine proper, with an arrangement of gears for giving the requisite speeds for the different kinds of bits, and means of rotating the drill rods and varying the pressure on the cutting tool. In addition to this, some



A Class "G-3" Gasoline Engine Driven "Calyx" Outfit

source of power is required; a derrick of some kind, with a hoist or winch for raising and lowering the drill rods and cutting tools; and a pump for circulating water.

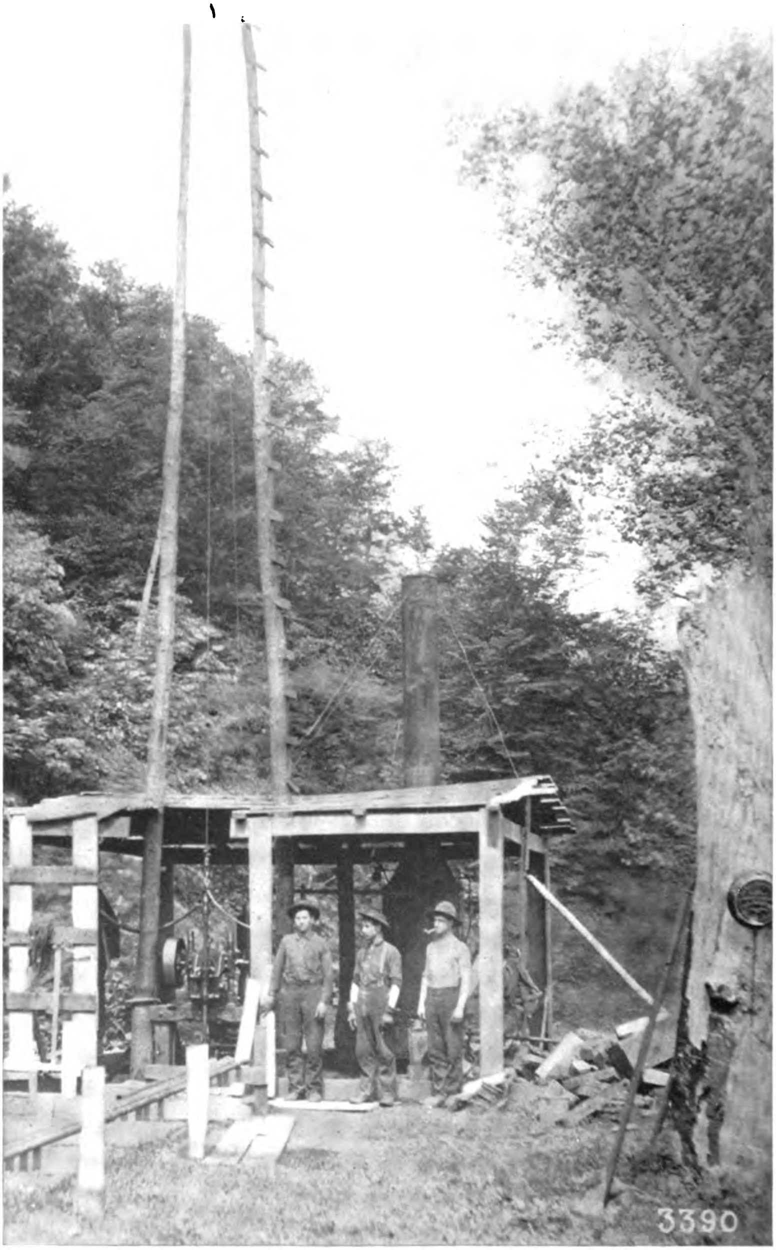
The several sizes and styles differ so in the mechanical details of the operating mechanism that no general description can be made covering all the modifications. The present machines, however, are the result of many years of experience and steady improvement, and offer all that may be desired in the way of simplicity, reliability and ease of management.



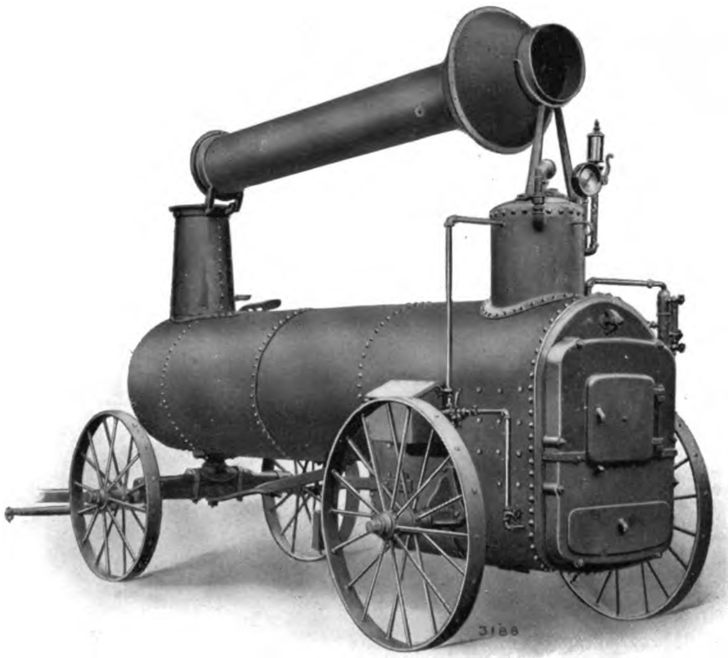
A Class "G-4" Power Driven "Calyx" Drill, with Electric Motor

The Prime Mover

The steam and gasoline engines furnished with the "Calyx" Drill are all of standard makes and are of a design best suited for core drill work. They carry with them a complete equipment, including all the necessary accessories, such as wrenches, oilers, etc. The horse-power, of course, varies with the size of the drill. The Company is prepared to furnish on order a "Calyx" Drill without engines; but unless there is some special reason to the contrary it is always best to have the engine furnished with the drill, as it is then sure to be properly arranged for driving both drill and hoist. Horse power equipments have a horse whim of an improved pattern. Hand power equipments are arranged for most convenient operation. Where the machine is to be belt driven from an independent source, the equipment includes a suitable belt pulley. The Company is also prepared to quote on outfits driven by electric or air motors.



Prospecting for Coal in West Virginia with the "Calyx" Drill



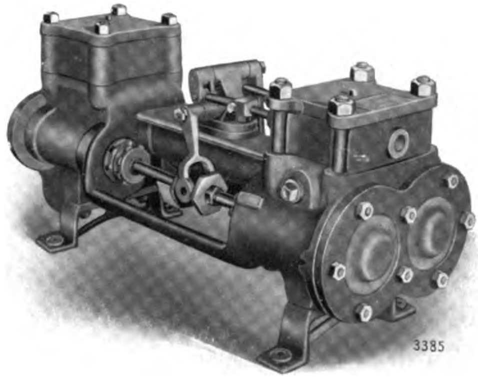
The Portable Boiler Furnished for Use with the "Calyx" Drill

The Boiler

When steam is to be used, the boiler is usually of the horizontal type mounted on wheels for convenience in moving. In some cases it is more convenient to use a vertical unmounted boiler, as it is light and can be carried on skids, or even rolled up and down hills if necessary. In extreme cases where transportation is very difficult, sectional boilers are sometimes used which can be taken apart and packed from place to place on mules. The Company is prepared to furnish boilers of any description to meet the conditions, in all cases giving the most satisfactory type. "Calyx" Drills are furnished with or without boilers. When the customer selects his own boiler it should be of a capacity not less than that listed in the Company's publications for the size of drill which is to be used.

A Class "BF-1" Calyx Outfit with Standard 58-Foot Steel Derrick

The Pump



The Pump Used with Steam Driven "Calyx" Outfits

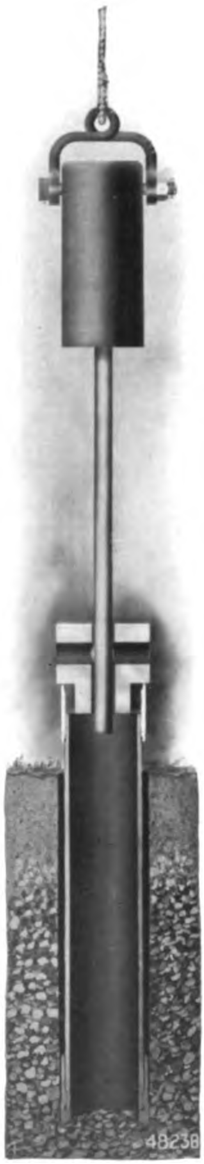
Pumps furnished are of standard pattern and fully equal to the rough and-ready service under which they must operate. With steam driven outfits a duplex direct - acting pump is furnished. Triplex power pumps are furnished with the gasoline and motor driven drills, and hand force-pumps with the hand power drills. Particular attention has been paid in all types to accessibility, and ease of repair and adjustment. The pump should be kept in good working order, as satisfactory operation depends very largely upon the water supply.

The Derrick

While a great many customers prefer to furnish their own derricks, usually made from timber found on the ground, the Company is prepared to furnish a steel derrick on all power driven "Calyx" outfits. With the small hand power drills, and where power drills are to be used for shallow holes only, a rough tripod of three timbers may be erected over the drill and will answer the purpose.

For moderately deep holes, 300 to 800 feet deep, a serviceable derrick can be made of two long timbers, 6 to 9 inches in butt measurement and 25 to 35 feet long, framed at the top with a strong cross-piece of about 6 x 6-inch section, and securely guyed.

For deep holes of 800 feet or more the Company's four-legged sectional steel derrick should be used. These are furnished in 38- and 58-foot lengths, which permit handling the drill rods in 30- and 50-foot lengths, respectively. These derricks are so constructed that each section is erected from the one below it; no steeple-jack or special rigging is required. They are made of standard steel forms and so designed that they can be put together with a minimum of time and labor.



Driving Pipe with Drive Weight
and Plain Drive Head

Driving Pipe with Drive Weight
and Drive Head with
Water Jet attached

Some Notes on Operation

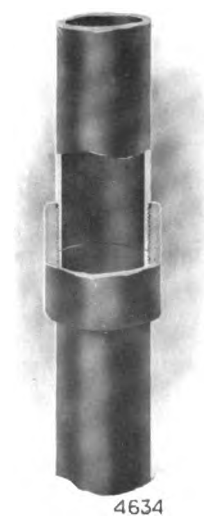
Complete instructions for setting up and operating "Calyx" Core Drills are given in a separate pamphlet which is furnished with each drill outfit; and with the aid of a "Calyx" Drill expert to start and instruct for a short time, the average operator should quickly manage the successful running of the machine. In this catalog only a brief outline of the drilling operations, and of the different devices employed, will be presented.

Starting a Hole

If the hole is to be started in solid rock from the surface, the drill spindle is connected to the short core barrel furnished with the machine, with the shot bit or the Davis cutter attached; and when the proper connections have been made at water swivel, hose, etc., the drill can be started at once. The short core barrel should be used only until a sufficient depth has been reached to permit the use of the long core barrel.

Drive Pipe or Stand Pipe

Where the rock does not come to the surface and the hole must be started through an over-burden of earth, gravel, or other soft material, some means of casing off the surface formation must be used. The size, kind and quantity of the pipe used depends upon local conditions. Where the over-burden is not very heavy and is comparatively free from boulders, ordinary gas pipe may be used. In the majority of cases, however, what is known as drive pipe is used. This may be standard or extra heavy, with long threads and outside couplings. Some users have preference for a flush joint pipe; but the Company does not recommend this for general work where only one size of pipe is used, as it will not stand so much driving and rotating as outside-coupled pipe.



Outside Coupled Drive Pipe

4635

Flush Joint Drive Pipe

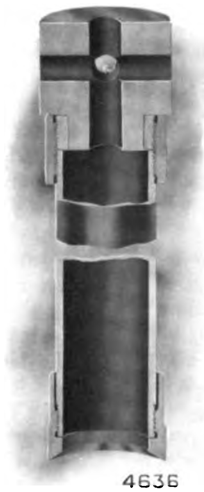
Any pipe used for casing off should be at least a half-inch larger than the maximum outside diameter of the core barrel. Casing should also be in odd lengths for greater convenience in handling under different conditions. When there is an over-burden of 100 feet or more to penetrate, it is best to start with a large pipe carried as far as possible and to finish with one or more smaller sizes. This is particularly necessary in bad boulder formations. It is sometimes more convenient to use a flush-joint pipe for reducing if a number of reductions have to be made, as this permits starting with a smaller diameter of casing.

Starting the Stand Pipe

Usually the hole is started with the regular drilling tools, using either the Davis cutter or the shot bit as may best suit the conditions, and carried to any practical depth. The stand pipe is then lowered into the hole thus made, and if the formation is sand or clay it can readily be driven as far as the drill has penetrated. After this start has been made, the pipe is driven or rotated down as described in the next section.

Driving the Stand Pipe

A drive head and drive shoe are screwed into the top and bottom respectively of the stand pipe. The drive head protects the end of the pipe from the blow of the drive weight, and the shoe protects the lower end of the pipe from bending or splitting. The pipe is then driven downward by the alternate rising and falling of the drive weight, used in connection with the hoist — a process very similar to that used in driving piles. Care must be exercised in adjusting the blow so that the pipe is not bent or split.



Drive Shoe and Plain Drive Head

After the pipe is driven as far as it will go, the tools are inserted and rotated, plenty of water being pumped down inside the rods to wash out all loose material in the hole. The hole is then carried down to a depth below the drive shoe determined by local conditions, after which the pipe is driven downward as before. This operation is continued until the over-burden has been passed and solid rock is encountered.

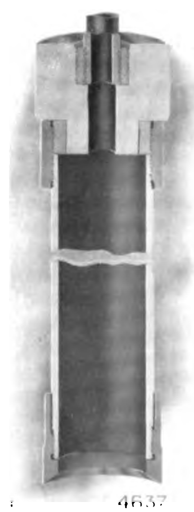
Rotating the Stand Pipe

In some materials, such as sand and small gravel, the stand pipe can be driven by rotation. In this case the drill spindle is connected to the drive head and the pipe rotated at slow speed. While rotating, a strong current of water is used.

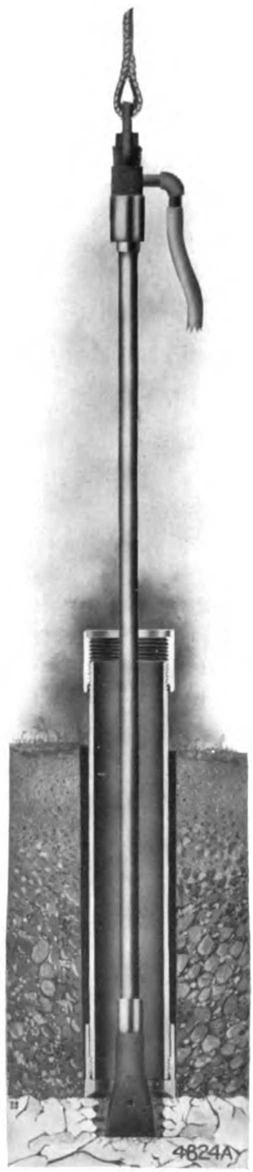
Whether driving or rotating is the best method of sinking the stand pipe can be determined only by experience. In the majority of cases both methods can be used. When bed rock has been reached, the stand pipe should be driven or rotated into it a sufficient distance to make a tight joint so that the water cannot escape, and earth or sand cannot get into the hole.

Casing

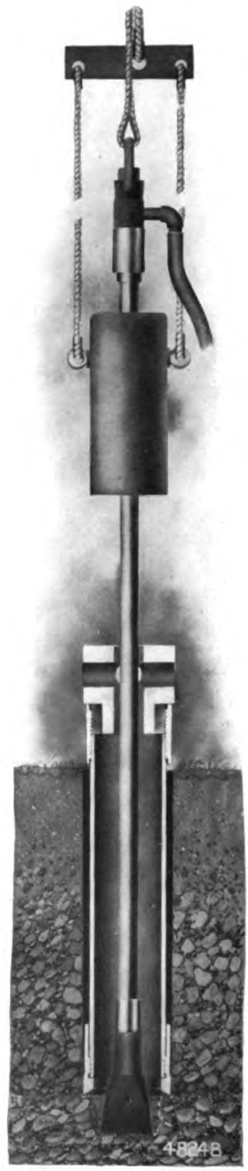
Ordinary well casing is not heavy enough to serve as drive pipe or stand pipe. But frequently a hole enters a layer of soft or caving material where it is necessary to insert a lining to keep the hole clear and the rods free. In such a case, the ordinary well casing is lowered into the hole, lining it through the soft layer. A smaller string of tools which will pass through the casing is then lowered, and the hole continued.



Drive Shoe and Drive Head with Drill Rod



Spudding with Chopping Bit, with Water Jet attached

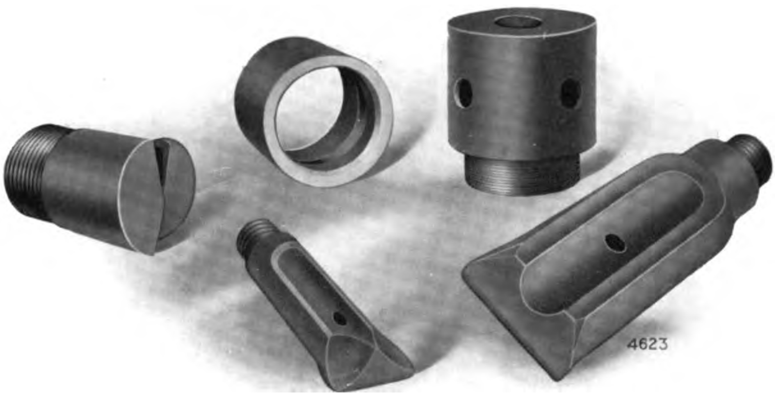


Driving Pipe in Combination with Chopping Bit and Water Jet.

Chopping or Spudding

When boulders or loose stones are encountered, they must be broken up or pushed out of the way, and for this purpose chopping bits of the best steel are furnished. They are bored in the center to provide a water-way for jetting, and screwed to the lower end of the drill rod. The rod and bit are then worked up and down, using the same process as used when driving the stand pipe.

The chopping bit will split or force aside boulders of ordinary size. But when boulders are encountered too large to be passed in this way, a hole should be drilled in them by means of the shot bit and a charge of dynamite exploded. This breaks up the boulder, making it possible for the chopping bit to penetrate.



Miser, Drive Shoe, Drive Head and Chopping Bits Used with the "Calyx" Drill

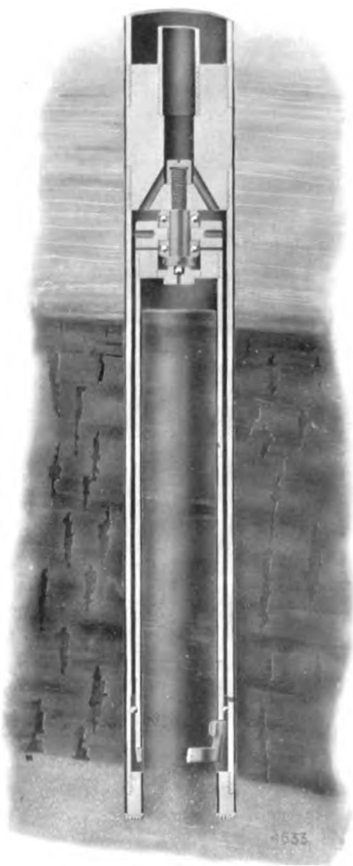
Drilling Through Crevices and Broken Rock

The statement has often been made that chilled shot and crushed steel can be successfully used only in drilling solid rock. Practise has shown, however, that it is not only possible to drill through such formations with the shot bit, but that this can be done in most cases better, more cheaply, and more quickly than by any other means. In such work very little water should be used and the shot should be fed continuously but only a few at a time. In this way it is possible to keep shot under the bit even when drilling through a vertical crevice. It is true that more shot will be required than when drilling in solid rock, but an experienced operator can do efficient work by this means; and the cost of additional shot for drilling in broken

rock is nothing in comparison to the cost of carbons for such work and the risk of losing them, where the diamond drill is used.

3½-inch Limestone Core Taken with the "Calyx" Drill, Showing the Ability of the Machine to Make Cores in Seamy Material

The Double Core Barrel



"Calyx" Double Core Barrel Used in Very Soft Materials

The double core barrel is a special device not used in hard rock. It has been designed principally for drilling in bituminous coal, but it can be used in any formation which is soft and friable, and liable to disintegrate in course of drilling. This tool is made in sizes for use with the regular 3, 4, 5, and 6-inch drills.

It consists simply of an outer and inner tube. The former is attached to the drill rod by means of the core barrel plug and is rotated the same as the cutting tools. The inner tube is suspended on a ball-bearing plug at the top, and centered by a ball bearing near the bottom; and it carries the core ring or lifter at its lower end. The core passes up through the bit into the inner barrel, where it is protected from the friction of the rotating parts and from the washing action of the water. An ample

water space is provided between the two tubes. This has been a very successful device and returns cores from the softest materials.

Sizes and Symbols

The "Calyx" Core Drill is furnished in the standard sizes given on pages 45 and 47, where condensed specifications of each size are also presented. Separate pamphlets deal with each of these different sizes.

The letters in the symbols are arbitrarily adopted. The numbers, however, have a meaning as follows:

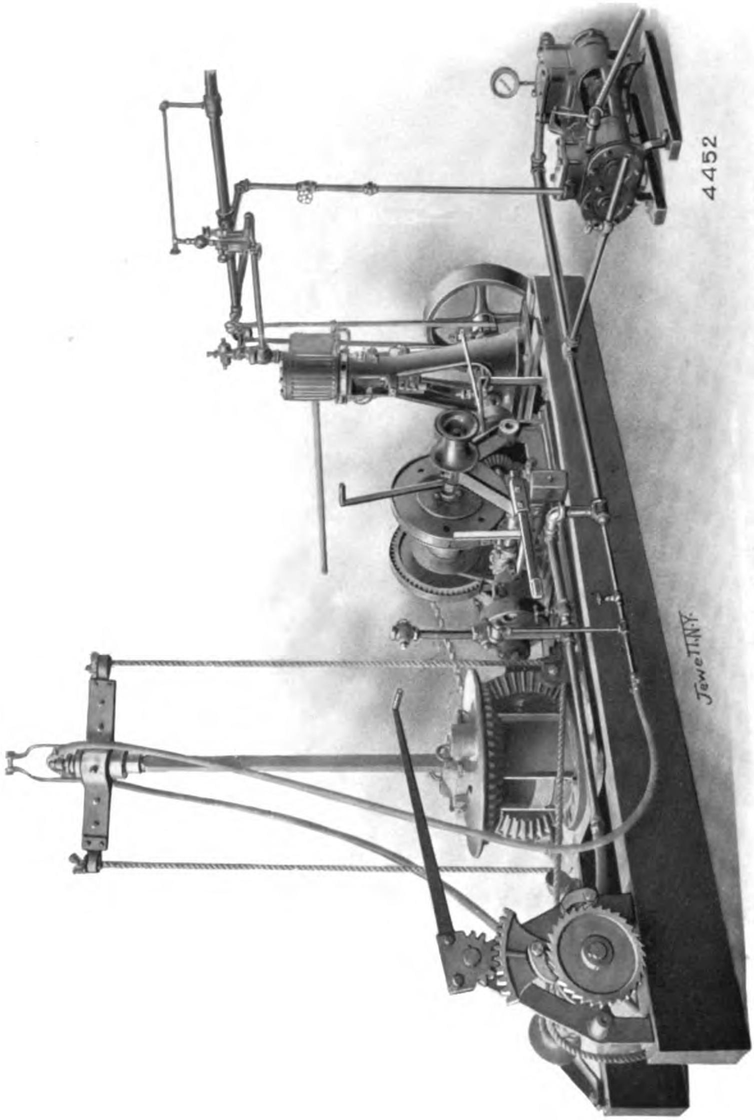
0 — hand power driven.
1 — steam engine driven.
2 — horse power driven.
3 — gasoline engine driven.
4 — power driven (belt or motor).

The separate pamphlets illustrate each type and list the equipment which is regularly furnished with each machine.

Information for Estimates

The Company frequently receives requests for estimates on "Calyx" Drill outfits which do not give sufficient information upon which to base an intelligent quotation. To facilitate matters, therefore, a Question Sheet is inserted in this pamphlet, outlining the information which should be furnished where an estimate is wanted on a drill to meet certain conditions. This sheet is separate and may be removed, filled in, and mailed to the Company.

3⅛-inch "Calyx" Core, Showing the Perfect Cores to be Made even through Pockets and Cavities



A Standard Class "BF-1" Steam Driven "Calyx" Outfit, with Drill, Hoist, Pump and Engine

Condensed Specifications

Standard Davis "Calyx" Drill Equipments

Class "AB"

Class "AB"-1	Steam Driven
Size of hole bored	4⅝″ to 20″
Diameter of core removed	3½″ to 18⅝″
Depth capacity	2,000 to 4,000 ft.
Engine Horse-power	20 to 40
Boiler Horse-power	25 to 50
Approximate Shipping Weight, complete (with 4,000 ft. drill rods)	80,000 lbs.

Class "AB"-4	Power Driven
Size of hole bored	4⅝″ to 20″
Diameter of core removed	3½″ to 18⅝″
Depth capacity	2,000 to 4,000 ft.
Horse-power required to operate	20 to 40
Approximate Shipping Weight, complete (with 4,000 ft. drill rods)	62,000 lbs.

Class "BF"

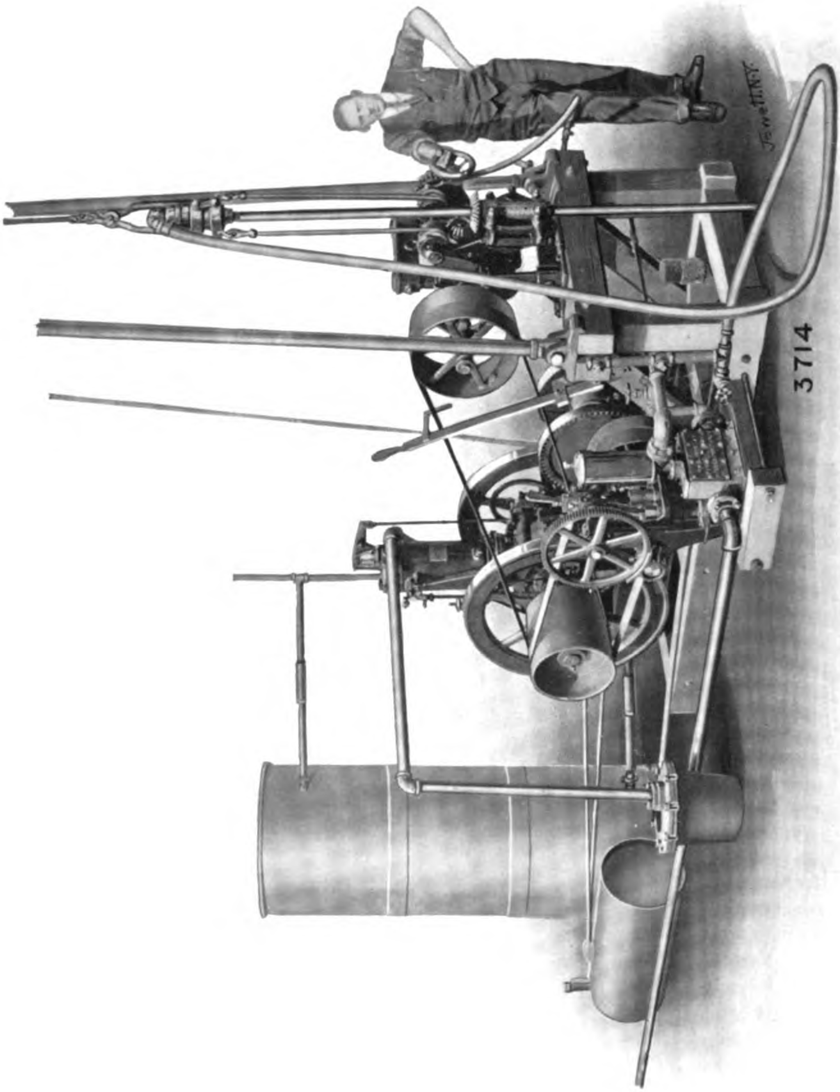
Class "BF"-1	Steam Driven
Size of hole bored	3⅝″ to 8¾″
Diameter of core removed	2½″ to 7½″
Depth capacity	1,000 to 1,500 ft.
Engine Horse-power	11
Boiler Horse-power	15
Shipping Weight, complete (with 1,500 ft. of drill rods)	25,350 lbs.

Class "BF"-4	Power Driven
Size of hole bored	3⅝″ to 8¾″
Diameter of core removed	2½″ to 7½″
Depth capacity	1,000 to 1,500 ft.
Horse-power required to operate	11 to 15
Shipping Weight, complete (with 1,500 ft. drill rods)	18 500 lbs.

Class "F"

Class "F-1"	Steam Driven
Size of hole bored	3⅛″ to 6¾″
Diameter of core removed	2⅛″ to 5⅝″
Depth capacity	500 to 800 ft.
Engine Horse-power	7 to 8
Boiler Horse-power	12
Shipping Weight, complete (with 800 ft. drill rods)	15,965 lbs.

Class "F-2"	Horse Power Driven
Size of hole bored	3⅛″ to 6¾″
Diameter of core removed	2⅛″ to 5⅝″
Depth capacity	200 to 500 ft.
Shipping Weight, complete (with 500 ft. drill rods)	8,580 lbs.



Class "F-3" Gasoline Engine Driven "Calyx" Drill Outfit

Class "F-3" **Gasoline Engine Driven**

Size of hole bored	3⅛″ to 6¼″
Diameter of core removed	2⅛″ to 5⅝″
Depth capacity	500 to 800 ft.
Engine Horse-power	6 to 9
Shipping Weight, complete (6 H.P. Engine) (with 500 ft. drill rods)	10,200 lbs.

Class "F-4" **Power Driven**

Size of hole bored	3⅛″ to 6¼″
Diameter of core removed	2⅛″ to 5⅝″
Depth capacity	500 to 800 ft.
Horse-power required to operate	7½ to 11
Shipping Weight, complete (with 800 ft. drill rods)	9,300 lbs.

Class "G"

Class "G-0" **Hand Power Driven**

Size of hole bored	2⅝″ to 3⅛″
Diameter of core removed	1⅝″ to 2⅛″
Depth capacity	250 ft.
Shipping Weight, complete (with 250 ft. drill rods)	3,000 lbs.

Class "G-1" **Steam Driven**

Size of hole bored	2⅝″ to 4⅝″
Diameter of core removed	1⅝″ to 3½″
Depth capacity	400 ft.
Engine Horse-power	4.8 to 7.8
Boiler Horse-power	8
Shipping Weight, complete (4.8 H.P. Engine) (with 400 ft. drill rods)	8,700 lbs.

Class "G-2" **Horse Power Driven**

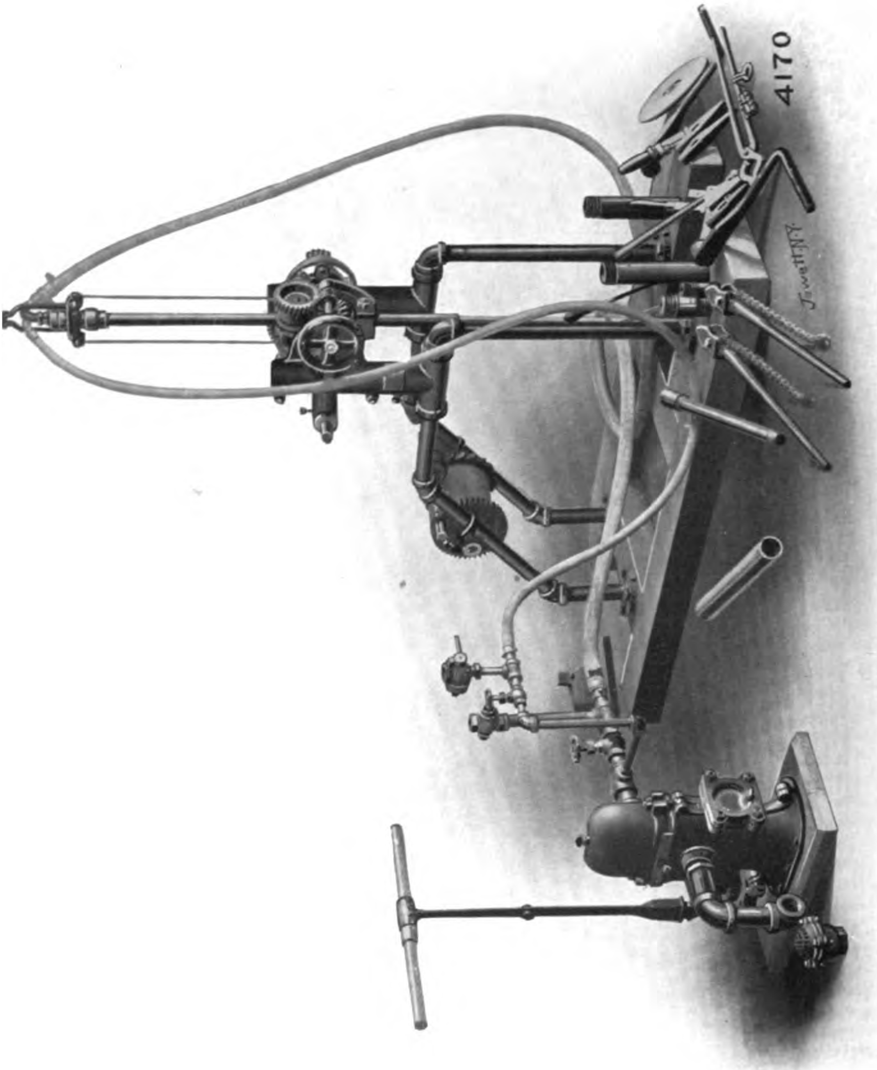
Size of hole bored	2⅝″ to 3⅛″
Diameter of core removed	1⅝″ to 2⅛″
Depth capacity	300 ft.
Shipping Weight, complete (with 300 ft. drill rods)	4,000 lbs.

Class "G-3" **Gasoline Engine Driven**

Size of hole bored	2⅝″ to 4⅝″
Diameter of core removed	1⅝″ to 3½″
Depth capacity	400 ft.
Engine Horse-power	4 to 6
Shipping Weight, complete (4 H.P. Engine) (with 400 ft. drill rods)	5,750 lbs.

Class "G-4" **Power Driven**

Size of hole bored	2⅝″ to 4⅝″
Diameter of core removed	1⅝″ to 3½″
Depth capacity	400 ft.
Horse-power required to operate	5 to 8
Shipping Weight, complete (with 400 ft. drill rods)	4,900 lbs.



Class "G-O" Hand Power Driven "Calyx" Drill Outfit

STILLINGS PRES

CLASS "G"

"CALYX DIAMONDLESS" CORE DRILLS

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

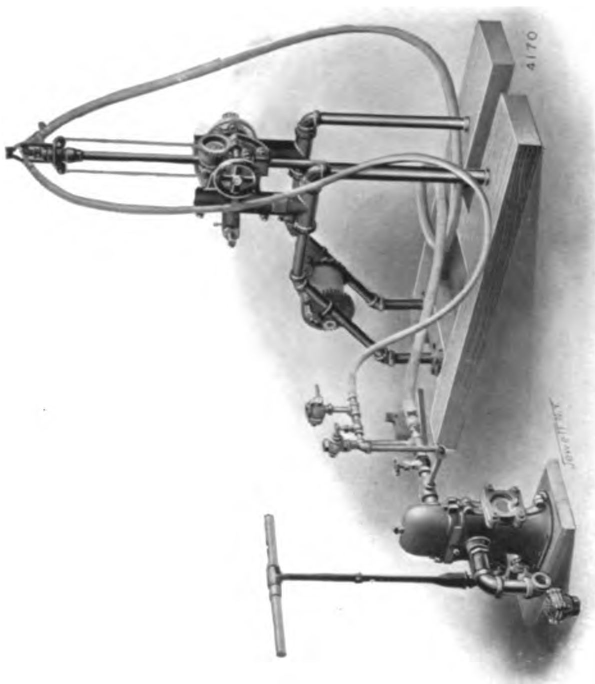
Form No. 9005. May, 1910.

THE Class "G" Drill represents the lightest type among the standard "Calyx" Core Drills. It is intended to meet the conditions demanding a comparatively light weight and ready portability where frequent moves are necessary; but it is nevertheless a heavy-duty machine, strongly built and adapted to hard, steady work with satisfactory results.

The Class "G-1" steam driven, the Class "G-3" gasoline engine driven and the Class "G-4" power driven drills have a depth capacity of 400 ft. The Class "G-0" hand power type is adapted for depths up to 250 feet and the Class "G-2" horse power driven machine will readily drill 300 feet.

In the pages following, the important features of each "G" type are given, together with the standard equipment furnished with each drill. All types have cut gears and bronze-bushed bearings. The construction throughout affords the necessary strength and rigidity. On Class "G-0" and "G-2" drills the frame is of steel; on the three other types it is of timber, strongly braced, the frame carrying drill head, hoist and engine or driving gear. The Class "G-1" and "G-3" drills can be furnished as portable outfits mounted on a truck as illustrated on page 12.

No derrick is regularly furnished with Class "G" "Calyx" drills. But on order a light 18-foot three-legged pipe derrick can be furnished, or a steel pipe derrick hinged to the drill frame, 27 feet in height, with the necessary guy wires. Class "G-1" steam driven drills can be furnished with a horizontal portable boiler or a vertical boiler. When the customer has available steam power the boiler may be omitted.



Standard Class "G-o" Hand Power "Calyx" Core Drill

Class "G-o" Hand Power Driven

Size of hole bored	2⅝" to 3⅛"
Diameter of core removed	1⅝" to 2⅛"
Depth capacity	250 ft.
Shipping Weight, complete (with 250 ft. drill rods)	3,000 lbs.

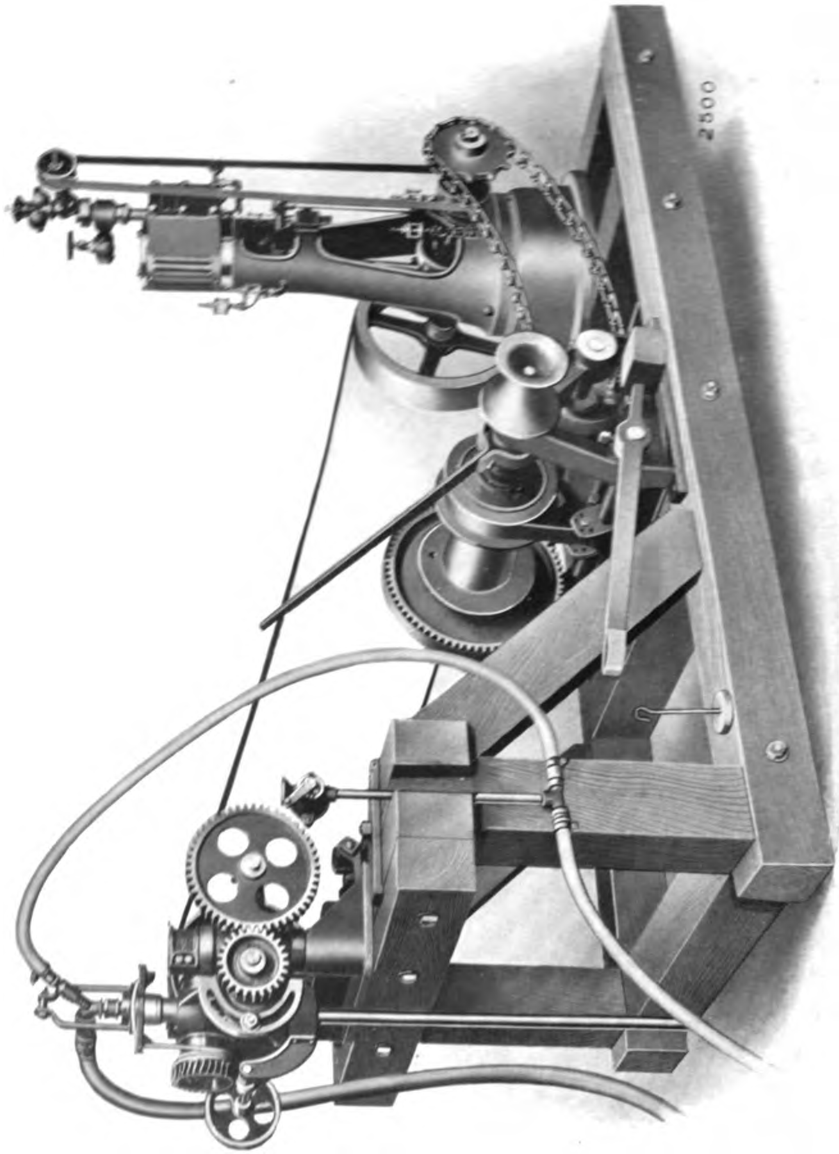
Regular Equipment

1 Drill arranged for turning and feeding the drill rods, mounted on an adjustable steel frame, hoisting winch with ratchet and pawl, and two cranks which fit either drill or hoist. Suitable pulley included for rotating by power when available.

1 Double-acting, brass-lined Hand-Pump

1 Drill Spindle
1 Water Swivel
2 Hoisting Swivels
1 Supporting Fork
1 Pressure Rope
1 Safety Shackle
1 Pair Sister Hooks
1 Pulley Block for Derrick
1 ⅜-inch Wire Rope 75 feet long
4 ⅜-inch Wire Rope Clamps and Bolts
1 1-inch Manila Rope 50 feet long
1 Shot Feed complete
All necessary Hose, Pipe and Fittings, including about 40 feet Suction Line for Pump
5 Drill Rods each 18 inches long, with Couplings
2 Drill Rods each 5 feet long, with Couplings
23 Drill Rods 10 feet long with Couplings
1 Core Barrel, short
1 Core Barrel, long
1 Core Barrel Plug
1 Calyx Barrel
4 Shot Bits
2 Davis Cutters
1 Dressing Plate
1 Flatter
1 Gouge
200 lbs. Chilled Shot
1 Bag Grout
1 Chopping Bit
1 Drive Weight
2 Fishing Taps
Necessary Matching Couplings

1 Combination Vise
1 Anvil
1 Forge
1 Pair Smith's Tongs
1 Machinist's Hammer
1 Hot Chisel
1 Cold Chisel
1 12-inch Monkey Wrench
1 24-inch Stillson Wrench
1 10-inch Stillson Wrench
2 No. 13 Chain Tongs
1 12-inch Hack Saw Frame
12 Hack Saw Blades
2 14-inch Flat Files
2 Hand Oilers
All Special Wrenches



Standard Class "G-1" Steam Driven "Calyx" Drill

Class "G-1"—Steam Driven

Size of hole bored	2⅝" to 4⅝"
Diameter of core removed	1⅝" to 3½"
Depth capacity	400 ft.
Engine Horse-power	4.8 to 7.8
Boiler Horse-power	8
Shipping Weight, complete (4.8 H. P. Engine and 400 ft. drill rods)	8,700 lbs.

Regular Equipment

1 Drill with sensitive feed, speed changing device for driving either Davis cutters or shot bits at the proper speed, and hinges for swinging drill away when driving casing. Cut gears and phosphor bronze bushings throughout.

1 No. 1 Friction Drum Hoist, with foot lever, brake, ratchet and pawl and winch-head.

1 4.8 H. P. Vertical Engine, single cylinder, 4½ x 5, with governor, sight-feed lubricators, drain cocks, oil cups, throttle valve and wrenches.

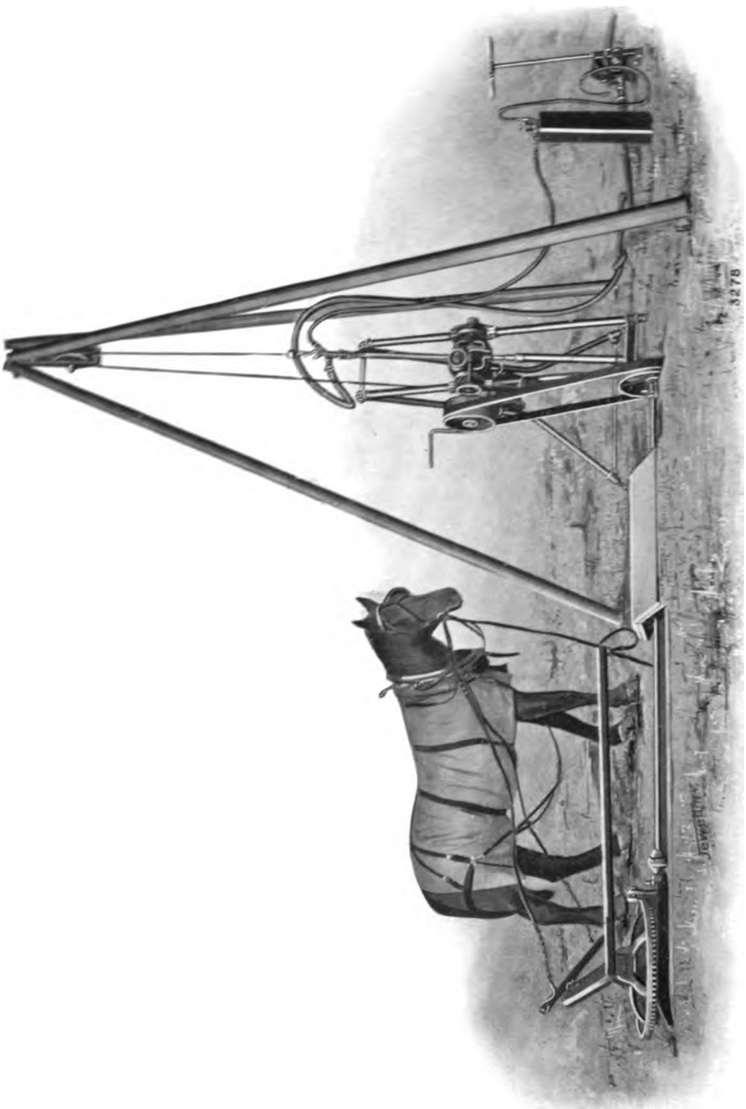
Drill, hoist and engine mounted on a substantial frame, with necessary belts, chains, sprockets, etc., for connecting drill and hoist with engine.

1 8 H. P. Horizontal Boiler mounted on iron wheels, complete; or
1 8 H. P. Vertical, Unmounted Boiler, complete.
(Specify type of Boiler preferred.)

1 Duplex Steam Pump, 3½ x 2¼ x 4, including grout cock, foot valve and strainer.

1 Drill Spindle
1 Water Swivel
2 Hoisting Swivels
1 Supporting Fork
1 Pressure Rope
1 Safety Shackle
1 Pair Sister Hooks
1 Pulley Block for Derrick
1 ⅜-inch Wire Rope 75 feet long
4 ⅜-inch Wire Rope Clamps and Bolts
1 1-inch Manila Rope 50 feet long
1 Shot Feed complete
All necessary Hose, Pipe and Fittings, including about 40 feet Suction Line for Pump
5 Drill Rods 18 inches long, with Couplings
2 Drill Rods 5 feet long, with Couplings
38 Drill Rods 10 feet long, with Couplings
1 Core Barrel, short
1 Core Barrel, long
1 Core Barrel Plug
1 Calyx Barrel
4 Shot Bits
2 Davis Cutters
1 Dressing Plate
1 Flatter
1 Gouge
200 lbs. Chilled Shot
1 Bag Grout
1 Chopping Bit
1 Drive Weight
2 Fishing Taps
Necessary Matching Couplings

1 Combination Vise
1 Anvil
1 Forge
1 Pair Smith's Tongs
1 Machinist's Hammer
1 Hot Chisel
1 Cold Chisel
1 12-inch Monkey Wrench
1 24-inch Stillson Wrench
1 10-inch Stillson Wrench
2 No. 13 Chain Tongs
1 12-inch Hack Saw Frame
12 Hack Saw Blades
2 14-inch Flat Files
2 Hand Oilers
All Special Wrenches



Standard Class "G-2" Horse Power Driven "Calyx" Drill

Class "G-2"—Horse Power Driven

Size of hole bored	$2\frac{5}{8}''$ to $3\frac{1}{8}''$
Diameter of core removed	$1\frac{5}{8}''$ to $2\frac{1}{8}''$
Depth capacity	300 ft.
Shipping Weight, complete (with 300 ft. drill rods) . .	4,000 lbs.

Regular Equipment

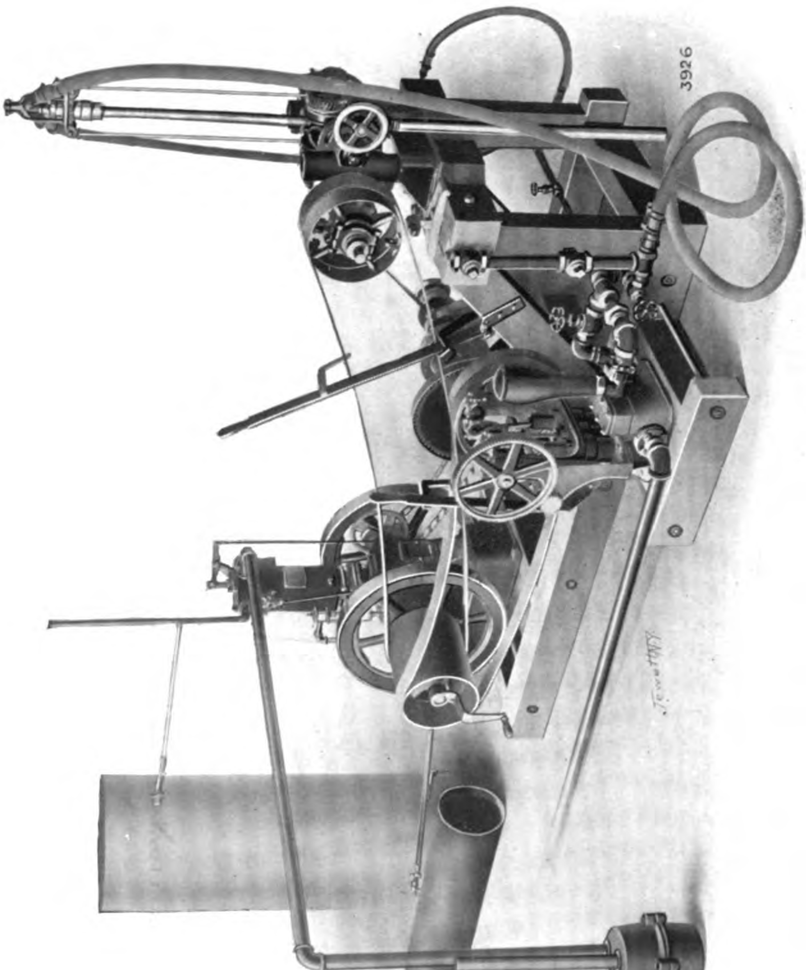
1 Drill arranged for turning and feeding drill rods, mounted on adjustable steel frame, also hoisting winch with ratchet and pawl and two cranks. Drill has cut gears and phosphor bronze bushings throughout.

1 No. 1 Calyx Horse Power, with one pole, shafting, pulley and belt.

1 Double-acting, brass lined Force Pump.

1 Drill Spindle
1 Water Swivel
2 Hoisting Swivels
1 Supporting Fork
1 Pressure Rope
1 Safety Shackle
1 Pair Sister Hooks
1 Pulley Block for Derrick
1 $\frac{3}{8}$-inch Wire Rope 75 feet long
4 $\frac{3}{8}$-inch Wire Rope Clamps and Bolts
1 1-inch Manila Rope 50 feet long
1 Shot Feed complete
All necessary Hose, Pipe and Fittings, including about 40 feet Suction Line for Pump
5 Drill Rods 18 inches long, with Couplings
2 Drill Rods 5 feet long, with Couplings
28 Drill Rods 10 feet long, with Couplings
1 Core Barrel, short
1 Core Barrel, long
1 Core Barrel Plug
1 Calyx Barrel
4 Shot Bits
2 Davis Cutters
1 Dressing Plate
1 Flatter
1 Gouge
200 lbs. Chilled Shot
1 Bag Grout
1 Chopping Bit
1 Drive Weight
2 Fishing Taps
Necessary Matching Couplings

1 Combination Vise
1 Anvil
1 Forge
1 Pair Smith's Tongs
1 Machinist's Hammer
1 Hot Chisel
1 Cold Chisel
1 12-inch Monkey Wrench
1 24-inch Stillson Wrench
1 10-inch Stillson Wrench
2 No. 13 Chain Tongs
1 12-inch Hack Saw Frame
12 Hack Saw Blades
2 14-inch Flat Files
2 Hand Oilers
All Special Wrenches



Standard Class "G-3" Gasoline Engine Driven "Calyx" Drill

Class "G-3"—Gasoline Engine Driven

Size of hole bored	2⅝" to 4⅝"
Diameter of core removed	1⅝" to 3½"
Depth capacity	400 ft.
Engine Horse-power	4 to 6
Shipping Weight, complete (4 H. P. Engine) (with 400 ft. drill rods	5,750 lbs.

Regular Equipment

1 Drill with sensitive feed, speed changing device for driving either Davis cutters or shot bits at the proper speed, and hinges for swinging drill away when driving casing. Cut gears and phosphor bronze bushings throughout.

1 No. 1 Friction Drum Hoist, with foot lever, brake, ratchet and pawl and winch-head.

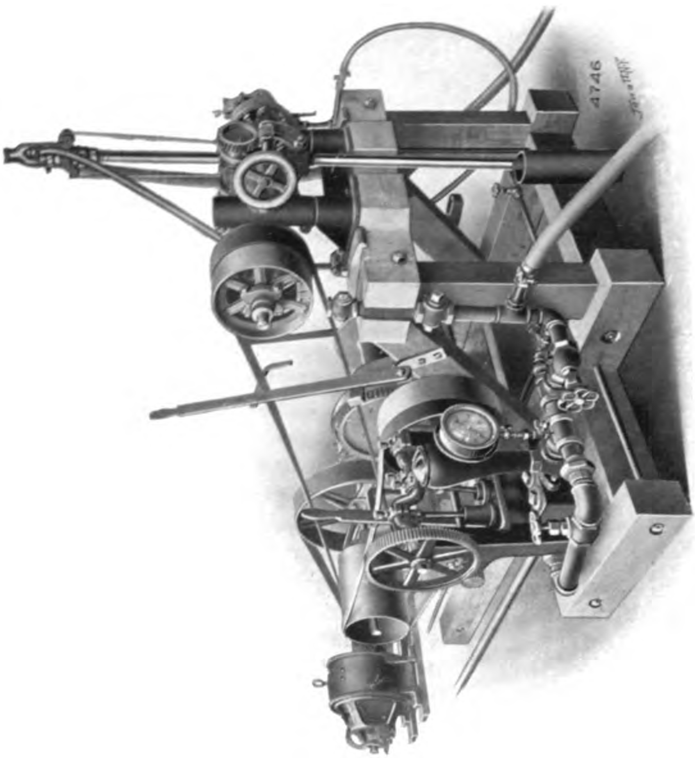
1 4 H. P. Gasoline Engine complete, with belts for driving drill and pump, and sprocket wheel and chain for driving hoist.

Drill, hoist and engine mounted on substantial frame, with necessary belts, sprockets, etc., for connecting drill, pump and hoist with engine.

1 Triplex Power Pump with tight and loose pulleys and by-pass.

1 Drill Spindle
1 Water Swivel
2 Hoisting Swivels
1 Supporting Fork
1 Pressure Rope
1 Safety Shackle
1 Pair Sister Hooks
1 Pulley Block for Derrick
1 ⅜-inch Wire Rope 75 feet long
4 ⅜-inch Wire Rope Clamps and Bolts
1 1-inch Manila Rope 50 feet long
1 Shot Feed complete
All necessary Hose, Pipe and Fittings, including about 40 feet Suction Line for Pump
5 Drill Rods 18 inches long, with Couplings
2 Drill Rods 5 feet long with Couplings
38 Drill Rods 10 feet long, with Couplings
1 Core Barrel, short
1 Core Barrel, long
1 Core Barrel Plug
1 Calyx Barrel
4 Shot Bits
2 Davis Cutters
1 Dressing Plate
1 Flatter
1 Gouge
200 lbs. Chilled Shot
1 Bag Grout
1 Chopping Bit
1 Drive Weight
2 Fishing Taps
Necessary Matching Couplings

1 Combination Vise
1 Anvil
1 Forge
1 Pair Smith's Tongs
1 Machinist's Hammer
1 Hot Chisel
1 Cold Chisel
1 12-inch Monkey Wrench
1 24-inch Stillson Wrench
1 10-inch Stillson Wrench
2 No. 13 Chain Tongs
1 12-inch Hack Saw Frame
12 Hack Saw Blades
2 14-inch Flat Files
2 Hand Oilers
All Special Wrenches



Standard Class "G-4" Power Driven "Calyx" Drill

Class "G-4"—Power Driven

Size of hole bored	2⅝" to 4⅝"
Diameter of core removed	1⅝" to 3½"
Depth capacity	400 ft.
Horse-power required to operate	5 to 8
Shipping Weight, complete (with 400 ft. drill rods) . .	4,900 lbs.

Regular Equipment

1 Drill with sensitive feed, speed changing device for driving either Davis cutters or shot bits at the proper speed, and hinges for swinging drill away when driving casing. Cut gears and phosphor bronze bushings throughout.

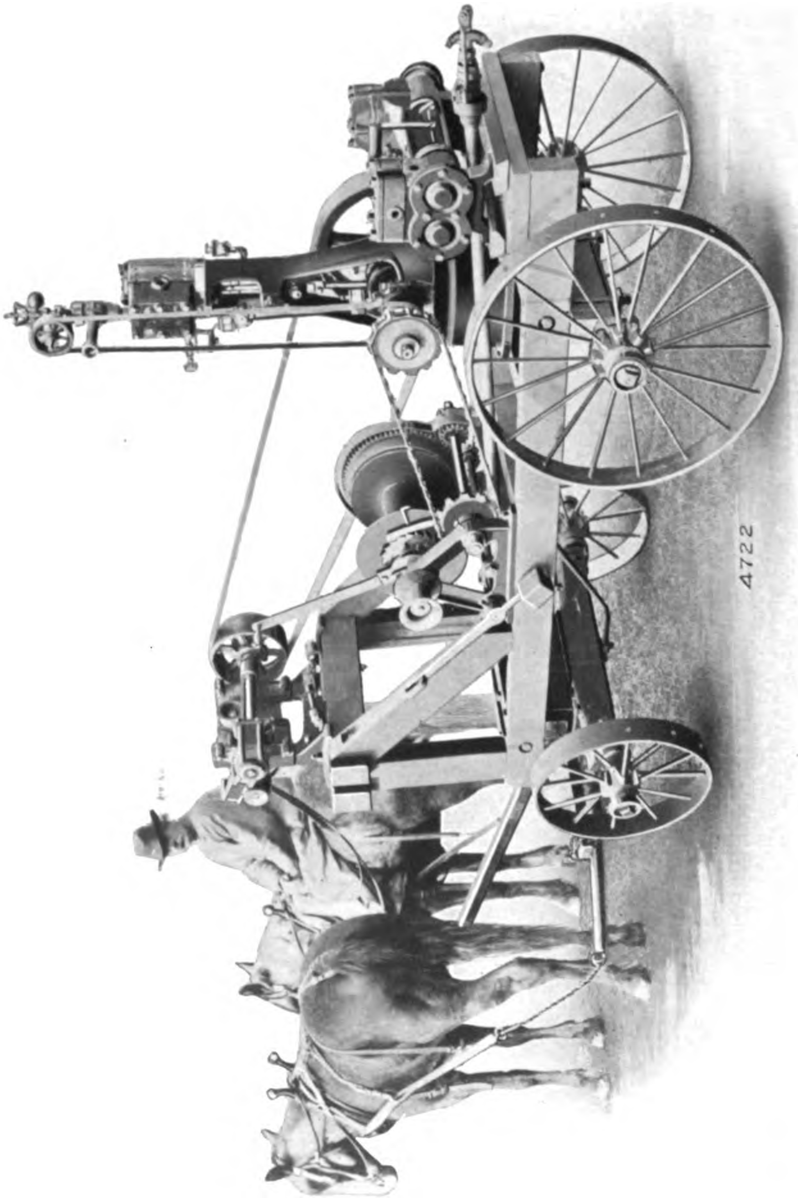
1 No. 1 Friction Drum Hoist, with foot lever, brake, ratchet and pawl and winch-head.

Drill, hoist, pump and countershaft with pulley, mounted on substantial frame with necessary belts, sprockets, etc., for connecting the drill, pump and hoist.

1 Triplex Power Pump with tight and loose pulleys and by-pass.

1 Drill Spindle
1 Water Swivel
2 Hoisting Swivels
1 Supporting Fork
1 Pressure Rope
1 Safety Shackle
1 Pair Sister Hooks
1 Pulley Block for Derrick
1 ⅜-inch Wire Rope 75 feet long
4 ⅜-inch Wire Rope Clamps and Bolts
1 1-inch Manila Rope 50 feet long
1 Shot Feed complete
All necessary Hose, Pipe and Fittings, including about 40 feet Suction Line for Pump
5 Drill Rods 18 inches long, with couplings
2 Drill Rods 5 feet long, with Coupiings
38 Drill Rods 10 feet long, with Couplings
1 Core Barrel, short
1 Core Barrel, long
1 Core Barrel Plug
1 Calyx Barrel
4 Shot Bits
2 Davis Cutters
1 Dressing Plate
1 Flatter
1 Gouge
200 lbs. Chilled Shot
1 Bag Grout
1 Chopping Bit
1 Drive Weight
2 Fishing Taps
Necessary Matching Couplings

1 Combination Vise
1 Anvil
1 Forge
1 Pair Smith's Tongs
1 Machinist's Hammer
1 Hot Chisel
1 Cold Chisel
1 12-inch Monkey Wrench
1 24-inch Stillson Wrench
1 10-inch Stillson Wrench
2 No. 13 Chain Tongs
1 12-inch Hack Saw Frame
12 Hack Saw Blades
2 14-inch Flat Files
2 Hand Oilers
All Special Wrenches



Portable Class "G-1" Steam Driven "Calyx" Core Drill on the Road

CLASS "F"

"CALYX DIAMONDLESS" CORE DRILLS

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Form No. 9004. May, 1910.

THE Class "F" Drill may be said to be the standard "Calyx" Drill, as more of this class are sold than of any of the other classes. Its great popularity indicates that it is an "all around" core drill, adapted to the larger percentage of core drill problems.

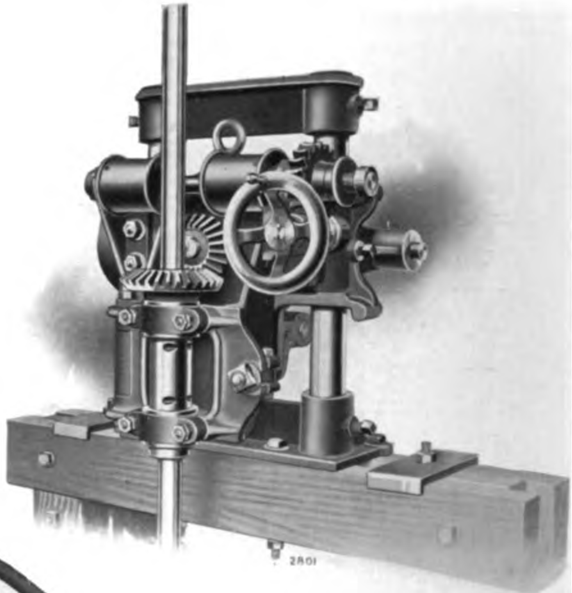
The steam, gasoline and power driven types of the Class "F" Drill have a depth capacity of 500 to 800 feet, as ordinarily equipped. But by using more power than the standard equipment affords, a skillful operator can go to a depth of 1,000 feet with these machines. Special engines and boilers of larger power can be supplied on order. The horse power driven Class "F-2" has a depth capacity of 200 to 500 feet.

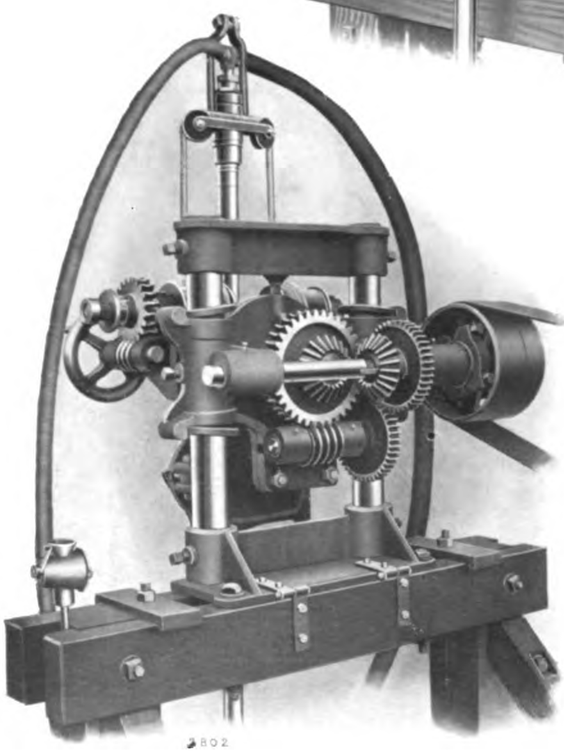
Drill and engine are mounted on a substantial timber frame. The drill head is compact and strongly built, with cut steel gears, dust-proof oil cups, and bronze-bushed bearings. The two speeds requisite for the Davis cutter and the shot bit are afforded. The Class "F" Drill is especially suited for angular drilling, up to 45° from the vertical, being provided with a simple and easily adjusted swing joint.

A 27-foot steel pipe derrick hinged to the drill frame is provided, with the necessary guy wires. Larger sectional steel derricks can be supplied on order in 38 and 58-foot lengths.

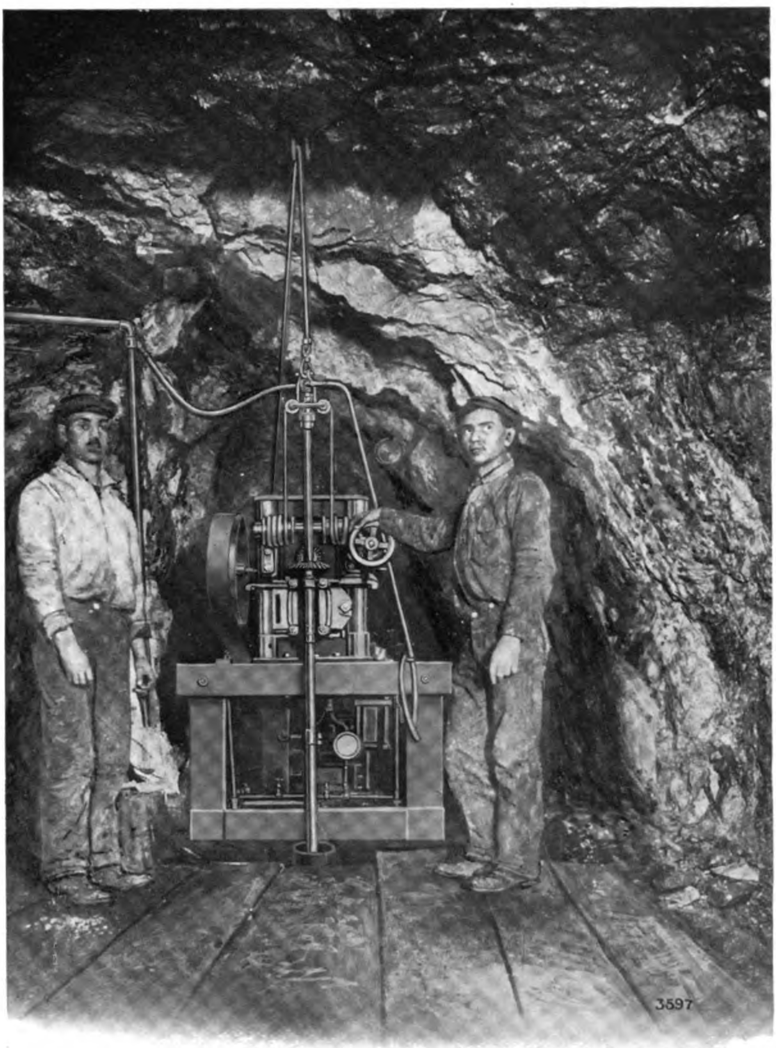
Class "F" Drills can also be supplied as portable outfits, mounted on trucks. One of these is illustrated on page 12. Portable boilers are furnished with these outfits.

Front View of Class "F" Drill Head

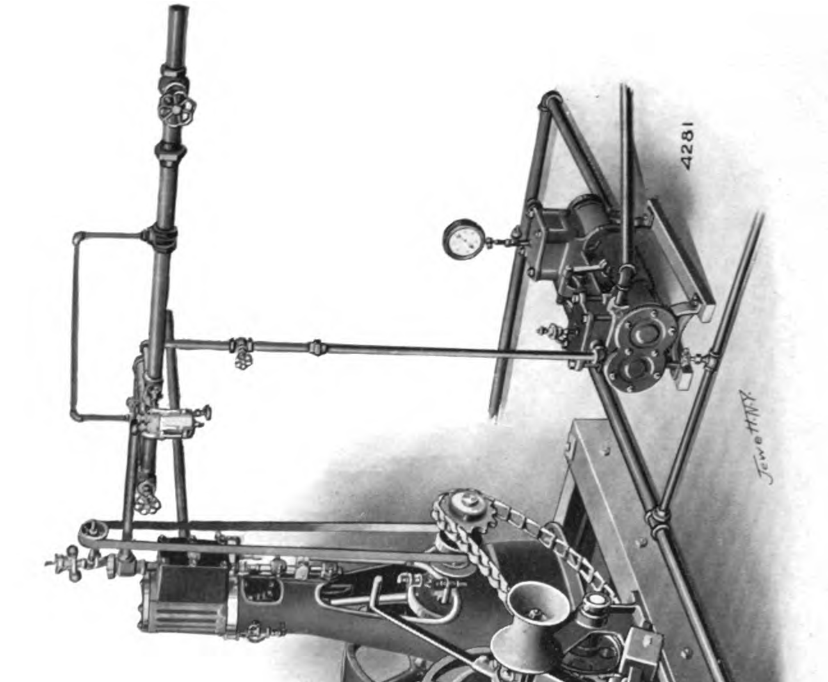




Rear View of Class "F" Drill Head, Showing Speed Changing Gears.



Prospecting Underground with the Class "F" Calyx Drill in an Arizona Copper Mine



Standard Class "F-1" Steam Driven "Calyx" Core Drill

Class "F-1" Calyx Drill—Steam Driven

Size of hole bored	3⅛" to 6¾"
Diameter of core removed	2⅛" to 5⅝"
Depth capacity	500 to 800 ft.
Engine Horse-power	7 to 8
Boiler Horse-power	12
Shipping Weight, complete (with 800 ft. of drill rods)	15,965 lbs.

Regular Equipment

1 Drill consisting of swivel plate, swing gate, sensitive feed, speed changing device, friction guide clutches, etc., cut gears, phosphor bronze bushings and self-closing dust-proof oil cups throughout.

1 No. 4 Friction Drum Hoist, with foot lever, brake, ratchet and pawl and winch-head.

1 7.8 H. P. Vertical Engine, single cylinder, 5 x 7 inches, with governor, sight feed lubricators, drain cocks, oil cups, throttle valve and wrenches.

Drill, hoist and engine mounted on substantial frame with necessary belts, sprockets, etc., for connecting drill and hoist with engine.

1 12 H. P. Horizontal Boiler mounted on iron wheels complete; or

1 12 H. P. Vertical Unmounted Boiler complete.

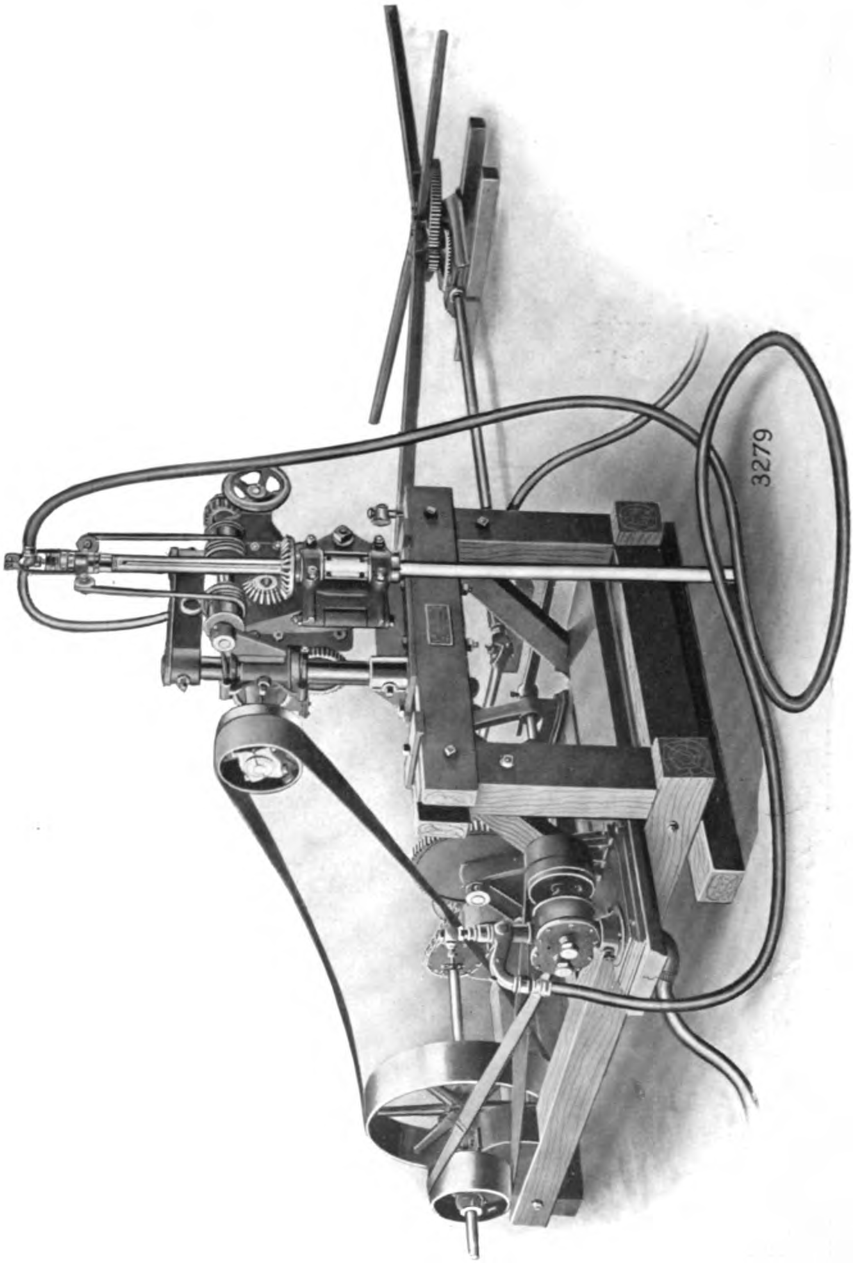
(Specify type of Boiler preferred.)

1 Duplex Steam Pump, 4½ x 3 x 4, including grout cock, foot valve, strainer and wrenches.

1 27-ft. Sectional Steel Derrick, with necessary guy wires.

1 Drill Spindle
1 Water Swivel
2 Hoisting Swivels
1 Safety Shackle
2 Davis Cutters
4 Shot Bits
1 Chopping Bit
1 Pair Casing Clamps
1 Core Barrel, short
1 Core Barrel, long
1 Core Barrel Plug
1 Calyx
Calyx Holder and Calyx Rod furnished with 4-inch tools and larger sizes.
Necessary Matching Couplings
1 Spanner Wrench
1 Socket Wrench
1 Supporting Fork
1 Drive Weight
5 Drill Rods each 2 feet long with Couplings
2 Drill Rods each 5 feet long with Couplings
77 Drill Rods each 10 feet long with Couplings
2 Pressure Ropes with Hooks and Clips
1 Gouge
1 Flatter
1 Dressing Plate
2 Fishing Taps
1 Shot Feed complete
1 Shot Feed Hose with Couplings
1 Wash Hose with Couplings
1 ⅜-inch Wire Rope 125 feet long
1 1-inch Manila Rope 75 feet long
1 Bag Grout
200 lbs. Chilled Shot
All necessary Pipe and Fittings for setting up and 40 feet Suction Pipe for Pump

1 Anvil
1 Combination Vise
1 Forge
1 Hot Chisel
1 Cold Chisel
1 Pair Smith's Tongs
1 Hammer
1 Monkey Wrench, 12 inches
1 Pair Sister Hooks
1 Hack Saw Frame
12 Hacksaws
2 14-inch Files
2 Oilers
1 Stillson Wrench, 24 inches
1 Stillson Wrench, 10 inches
2 Chain Pipe Wrenches, No. 13
1 10-inch Sheave Pulley Block



Standard Class "F-2" Horse Power Driven "Calyx" Core Drill

Class "F-2" Calyx Drill—Horse Power Driven

Size of hole bored	3⅛" to 6¾"
Diameter of core removed	2⅛" to 5⅝"
Depth capacity	200 to 500 ft.
Shipping Weight, complete (with 500 ft. of drill rods)	8,580 lbs.

Regular Equipment

1 Drill consisting of swivel plate, swing gate, sensitive feed, speed changing device, friction guide clutches, etc., cut gears, phosphor bronze bushings and self-closing, dust-proof oil cups throughout.

1 No. 4 Friction Drum Hoist, with foot lever, brake, ratchet and pawl and winch-head.

1 No. 1 Calyx Horse Power, for two horses, with two sweeps and necessary shafting with universal joints.

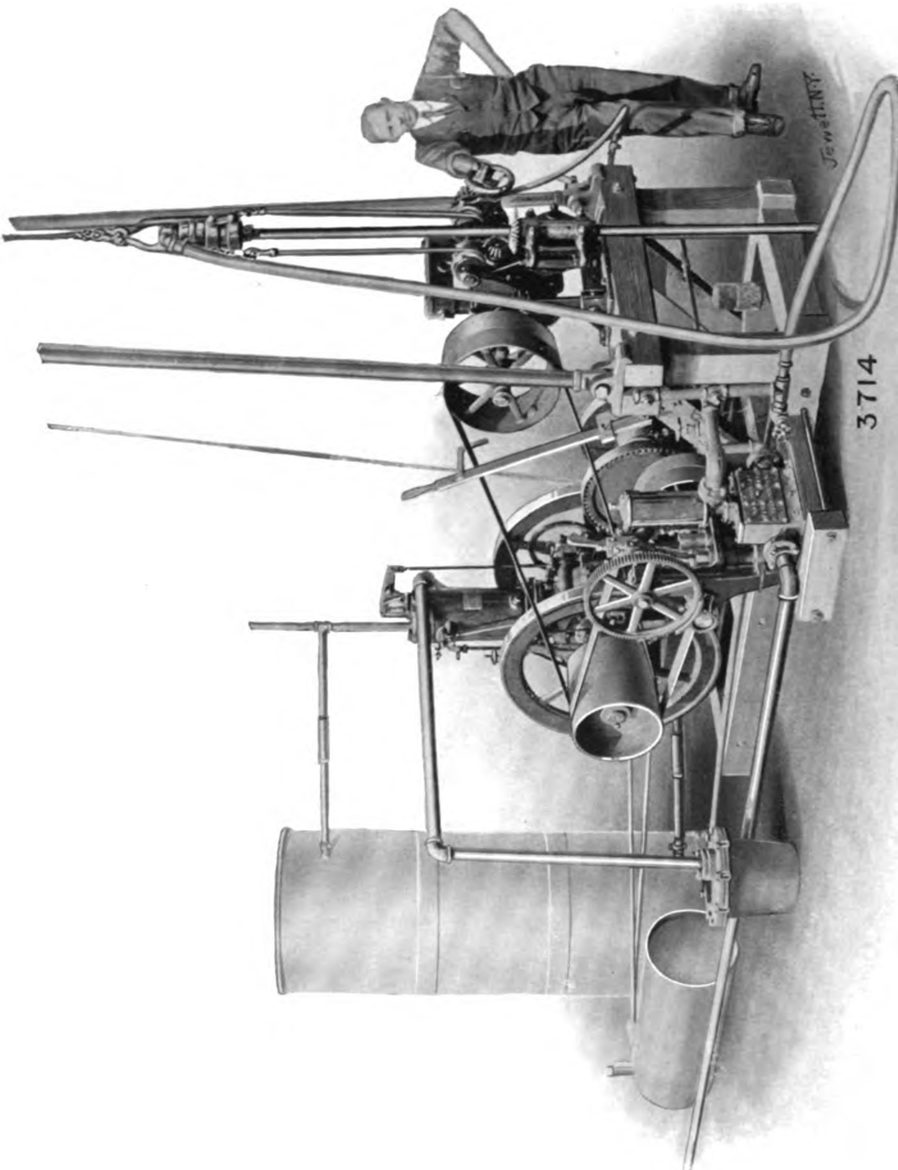
Drill, Hoist, countershaft and pump mounted on substantial frame, with necessary belts, sprockets, etc., for connecting drill, hoist and pump with horse power.

1 Triplex Power Pump with tight and loose pulleys and by-pass.

1 27-foot Sectional Steel Derrick, with necessary guy-wires.

1 Drill Spindle
1 Water Swivel
2 Hoisting Swivels
1 Safety Shackle
2 Davis Cutters
4 Shot Bits
1 Chopping Bit
1 Pair Casing Clamps
1 Core Barrel, short
1 Core Barrel, long
1 Core Barrel Plug
1 Calyx
Calyx Holder and Calyx Rod furnished with 4-inch tools and larger sizes
Necessary Matching Couplings
1 Spanner Wrench
1 Socket Wrench
1 Supporting Fork
1 Drive Weight
5 Drill Rods each 2 feet long with Couplings
2 Drill Rods each 5 feet long with Couplings
47 Drill Rods each 10 feet long with Couplings
2 Pressure Ropes with Hooks and Clips
1 Gouge
1 Flatter
1 Dressing Plate
2 Fishing Taps
1 Shot Feed complete
1 Shot Feed Hose with Couplings
1 Wash Hose with Couplings
1 ⅜-inch Manila Rope 125 feet long
1 1-inch Manila Rope 75 feet long
1 Bag Grout
200 lbs. Chilled Shot
All necessary Pipe and Fittings for setting up and 40 feet Suction Pipe for Pump

1 Anvil
1 Combination Vise
1 Forge
1 Hot Chisel
1 Cold Chisel
1 Pair Smith's Tongs
1 Hammer
1 Monkey Wrench, 12 inches
1 Pair Sister Hooks
1 Hack Saw Frame
12 Hacksaws
2 14-inch Files
2 Oilers
1 Stillson Wrench, 24 inches
1 Stillson Wrench, 10 inches
2 Chain Pipe Wrenches, No. 13
1 10-inch Sheave Pulley Block



Standard Class "F-3" Gasoline Engine Driven "Calyx" Core Drill

Class "F-3" Calyx Drill—Gasoline Engine Driven

Size of hole bored	3⅛" to 6¾"
Diameter of core removed	2⅛" to 5⅝"
Depth capacity	500 to 800 ft.
Engine Horse-power	6 to 9
Shipping Weight, complete (with 6 H. P. engine and 500 ft. of drill rods)	10.200 lbs.

NOTE—A 9 H. P. engine is required for 800-foot depth.

Regular Equipment

1 Drill consisting of swivel plate, swing gate, sensitive feed, speed changing device, friction guide clutches, etc., cut gears, phosphor bronze bushings and self-closing dust-proof oil cups throughout.

1 No. 4 Friction Drum Hoist, with foot lever, brake, ratchet and pawl and winch-head.

1 6 H. P. Gasoline Engine complete, with belt for driving drill and pump, and sprocket wheel and chain for driving hoist.

(For drilling to a depth of 800 ft. a 9 H. P. Gasoline Engine is furnished.)

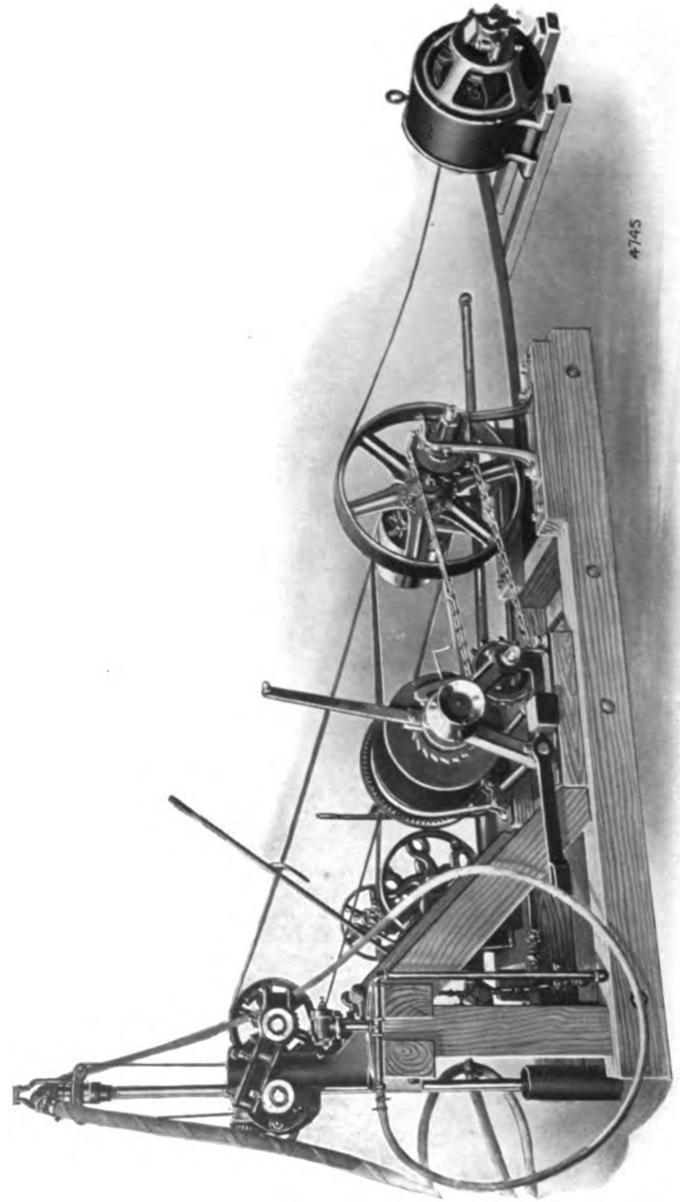
Drill, hoist and engine mounted on substantial frame with necessary belts, sprockets, etc., for connecting drill, pump and hoist with engine.

1 Triplex Power Pump with tight and loose pulleys and by-pass.

1 27-foot Sectional Steel Derrick, with necessary guy-wires.

1 Drill Spindle
1 Water Swivel
2 Hoisting Swivels
1 Safety Shackle
2 Davis Cutters
4 Shot Bits
1 Chopping Bit
1 Pair Casing Clamps
1 Core Barrel, short
1 Core Barrel, long
1 Core Barrel Plug
1 Calyx
Calyx Holder and Calyx Rod furnished with 4-inch tools and larger sizes
Necessary Matching Couplings
1 Spanner Wrench
1 Socket Wrench
1 Supporting Fork
1 Drive Weight
5 Drill Rods each 12 feet long with Couplings
2 Drill Rods each 5 feet long with Couplings
47 Drill Rods each 10 feet long with Couplings
(30 additional 10-ft. rods furnished with 800 ft. equipment.)
2 Pressure Ropes with Hooks and Clips
1 Gouge
1 Flatter
1 Dressing Plate
2 Fishing Taps
1 Shot Feed complete
1 Shot Feed Hose with Couplings
1 Wash Hose with Couplings
1 ⅜-inch Wire Rope 125 feet long
1 1-inch Manila Rope 75 feet long
1 Bag Grout
200 lbs. Chilled Shot
All necessary Pipe and Fittings for setting up and 40 feet Suction Pipe for Pump

1 Anvil
1 Combination Vise
1 Forge
1 Hot Chisel
1 Cold Chisel
1 Pair Smith's Tongs
1 Hammer
1 Monkey Wrench, 12 inches
1 Pair Sister Hooks
1 Hack Saw Frame
12 Hacksaws
2 14-inch Files
2 Oilers
1 Stillson Wrench, 24 inches
1 Stillson Wrench, 10 inches
2 Chain Pipe Wrenches, No. 13
1 10-inch Sheave Pulley Block



Standard Class "F-4" Power Driven "Calyx" Core Drill with Electric Motor

Class "F-4" Calyx Drill—Power Driven

Size of hole bored	3⅛" to 6¾"
Diameter of core removed	2⅛" to 5⅝"
Depth capacity	500 to 800 ft.
Horse power required	7½ to 11
Shipping Weight, complete (with 800 ft. of drill rods)	9,300 lbs.

Regular Equipment

1 Drill consisting of swivel plate, swing gate, sensitive feed, speed changing device, friction guide clutches, etc., cut gears, phosphor bronze bushings and self-closing dust-proof oil cups throughout.

1 No. 4 Friction Drum Hoist, with foot lever, brake, ratchet and pawl and winch-head.

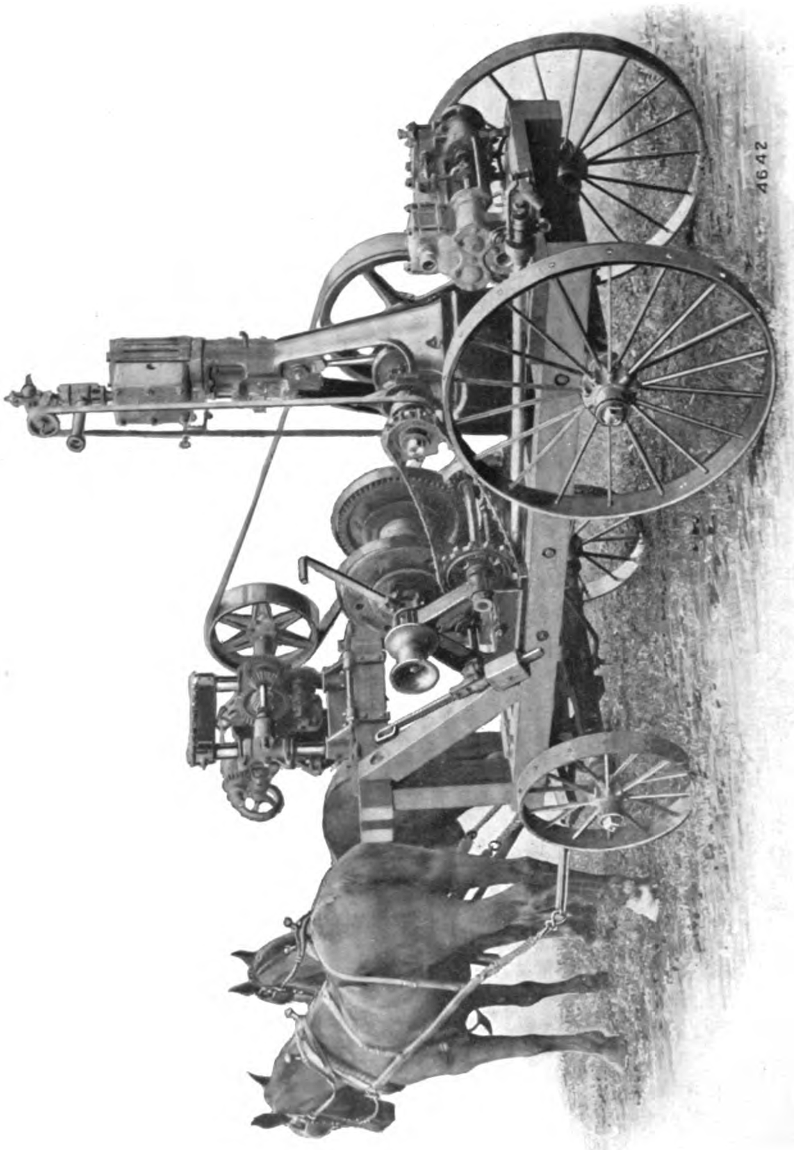
Drill, hoist, pump and countershaft with pulley, mounted on substantial frame with necessary belts, sprockets, etc., for connecting drill, pump and hoist.

1 Triplex Power Pump with tight and loose pulleys and by-pass.

1 27-foot Sectional Steel Derrick, with necessary guy-wires.

1 Drill Spindle
1 Water Swivel
2 Hoisting Swivels
1 Safety Shackle
2 Davis Cutters
4 Shot Bits
1 Chopping Bit
1 Pair Casing Clamps
1 Core Barrel, short
1 Core Barrel, long
1 Core Barrel Plug
1 Calyx
Calyx Holder and Calyx Rod furnished with 4-inch tools and larger sizes
Necessary Matching Couplings
1 Spanner Wrench
1 Socket Wrench
1 Supporting Fork
1 Drive Weight
5 Drill Rods each 2 feet long with Couplings
2 Drill Rods each 5 feet long with Couplings
77 Drill rods each 10 feet long with couplings
2 Pressure Ropes with Hooks and Clips
1 Gouge
1 Flatter
1 Dressing Plate
2 Fishing Taps
1 Shot Feed complete
1 Shot Feed Hose with Couplings
1 Wash Hose with Couplings
1 ⅜-inch Wire Rope 125 feet long
1 1-inch Manila Rope 75 feet long
1 Bag Grout
200 lbs. Chilled Shot
All necessary Pipe and Fittings for setting up and 40 feet Suction Pipe for Pump

1 Anvil
1 Combination Vise
1 Forge
1 Hot Chisel
1 Cold Chisel
1 Pair Smith's Tongs
1 Hammer
1 Monkey Wrench, 12 inches
1 Pair Sister Hooks
1 Hack Saw Frame
12 Hacksaws
2 14-inch Files
2 Oilers
1 Stillson Wrench, 24 inches
1 Stillson Wrench, 10 inches
2 Chain Pipe Wrenches, No. 13
1 10-inch Sheave Pulley Block



Portable Class "F-1" Steam Driven "Calyx" Core Drill on the Road

CLASS "BF"

"CALYX DIAMONDLESS" CORE DRILLS

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Form No. 9006. May, 1910.

THE Class "BF" Calyx Core Drill meets the demand for a larger drill than the Class "F" or Class "G." It is intended for heavier work, larger cores, and deeper holes, having a capacity of 1,500 feet with 4-inch tools. The maximum diameter of hole drilled by the "BF" Drill is 10 inches. The drill is pre-eminently a surface prospecting drill, but is also a very popular type and size for putting down water wells through hard formations, when equipped with 6- or 8-inch tools.

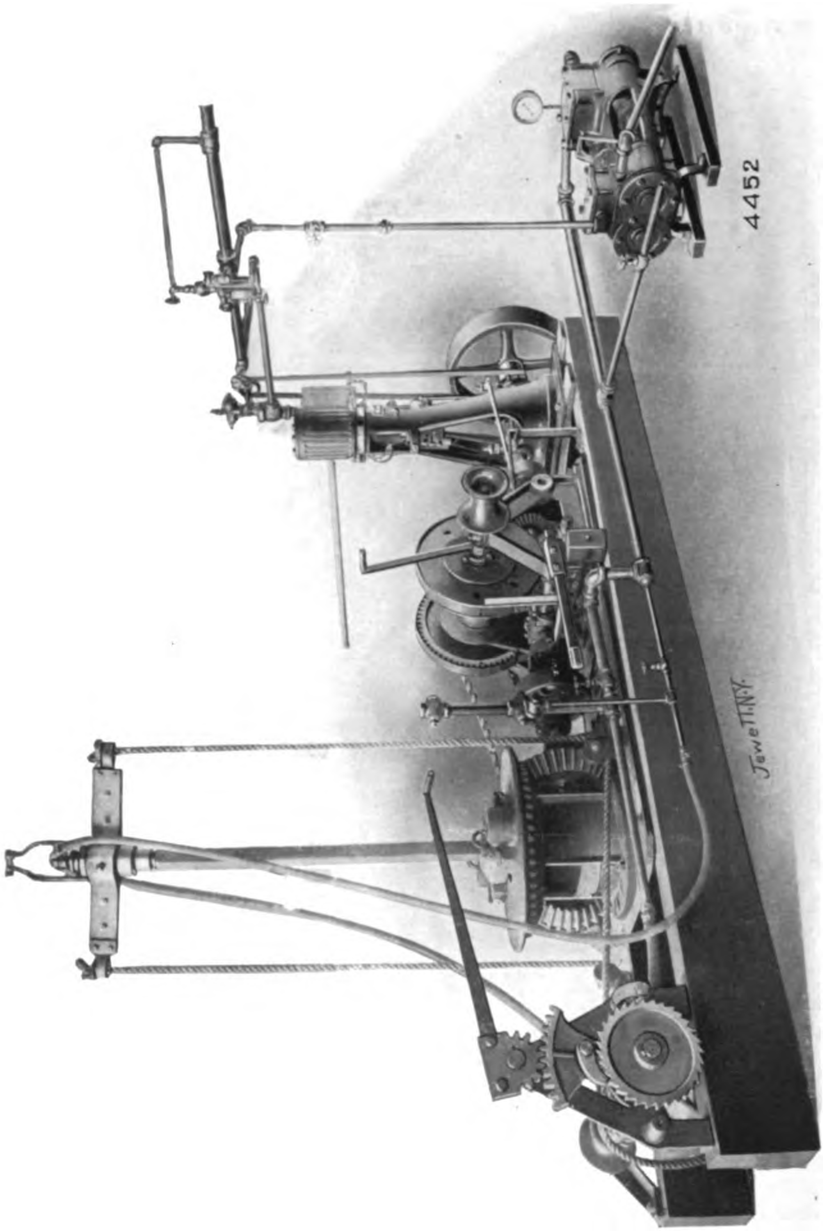
The Class "BF" is offered in two types—"BF-1," steam-driven, and the "BF-4," power-driven. In the "BF-1" machine the vertical, single-cylinder engine is direct-connected to both drill and hoist, either of which is thrown in or out of gear by shifting levers. The frame carries the engine, hoist, drill head and pressure device. The pump is usually separate from the frame.

In the "BF-4," when driven by electric motor, the latter is placed on the same frame with the rest of the machine and direct geared to the main shaft. Where the drill is to be driven by gasoline engine, independent steam engine, or where the type or speed of the motor does not suit the direct-drive arrangement, the necessary countershaft and pulleys for driving the drill by belt are supplied.

While 1,500 feet is the listed maximum depth of the "BF-1" Drill, in the hands of a competent and experienced operator it will drill to a depth of 1,800 or 2,000 feet.

The "BF" mounted outfit, as shown on page 6, is particularly well adapted, and is extensively used, for well work. It is very compact, all essential parts being on one truck and so arranged that the operator can, without moving from his position by the side of the drill, manipulate all steam and water valves, shifting levers, pressure devices, etc.

The wide range of diameter of holes which this type will bore, and its adaptability for shallow or deep holes, combined with portability and compactness, make it an ideal outfit for contractors or for any one desiring a drill that will cover a diversified field of core drill work.



A Standard "BF-1" Steam Driven "Calyx" Outfit with Drill, Hoist, Pump and Engine

Class "BF-1"—Steam Driven

Size of hole bored	3⅝" to 8¾"
Diameter of core removed	2½" to 7½"
Depth capacity	1,000 to 1,500 ft.
Engine Horse-power	11
Boiler Horse-power	15
Shipping Weight, complete (with 1,500 ft. of drill rods)	25,350 lbs.

Regular Equipment

1 "BF" Rotating Device, complete with bed-plate.

1 No. 4 Friction Drum Hoist, with foot lever, brake, ratchet and pawl and winch-head.

1 11-H. P. Vertical Single-Cylinder Engine, 6 x 7 inches, with governor, sight-feed lubricator, drain cocks, oil cups, throttle valve and wrenches.

Drill, hoist and engine mounted on substantial frame, drill and hoist being direct connected with engine.

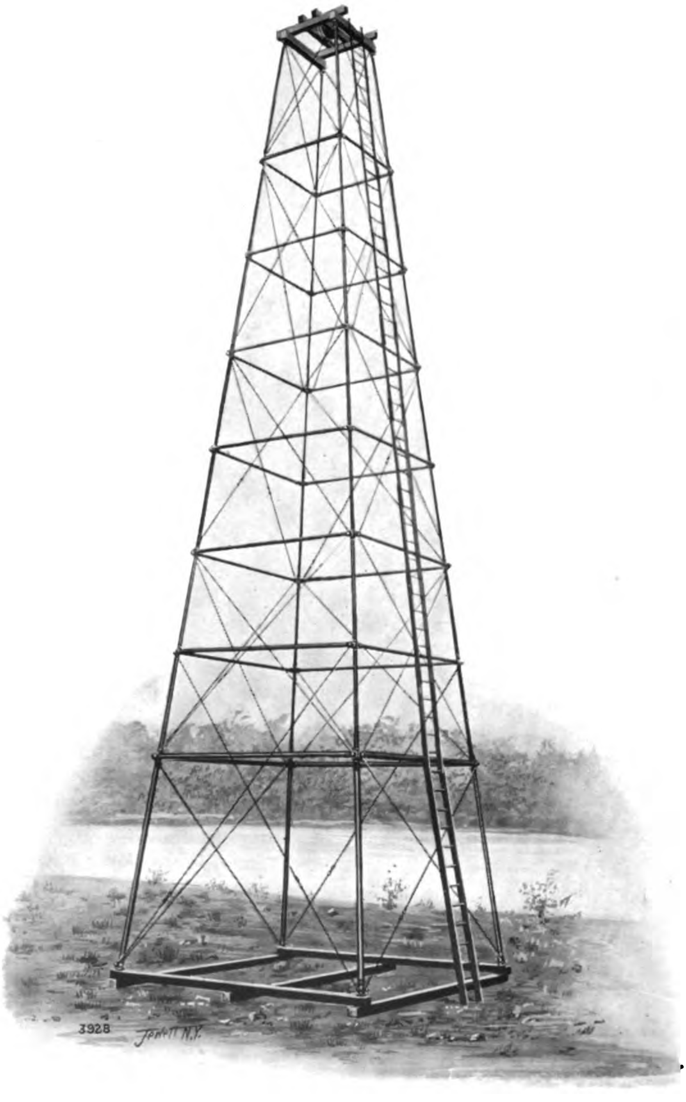
1 15-H. P. Horizontal Boiler on wheels, complete; or
1 15-H.P. Vertical, Unmounted Boiler, complete.
(Specify type of Boiler preferred.)

1 Duplex Steam Pump, 6 x 4 x 6, including grout cock, foot valve, strainer and wrenches.

1 Tubular Sectional Steel Derrick, 38 ft. high, complete with top and bottom timbers, sheaves and ladder.

1 Rotating Rod 7 feet long
1 Rotating Rod 15 feet long
1 Water Swivel
2 Hoisting Swivels
1 Safety Shackle
2 Davis Cutters
4 Shot Bits
1 Chopping Bit
1 Pair Casing Clamps
1 Core Barrel, short
1 Core Barrel, long
1 Core Barrel Plug
1 Calyx
Calyx Holder and Calyx Rod furnished with 4-inch tools and larger sizes
1 Drive Weight
Necessary Matching Couplings
1 Drill Rod 2 feet long with Coupling
2 Drill Rods each 5 feet long with Couplings
147 Drill Rods each 10 feet long with Couplings
2 Supporting Forks
1 Pressure Rope
1 Gouge
1 Flatter
1 Dressing Plate
2 Fishing Taps
1 Shot Feed complete
1 Shot Feed Hose with Couplings
1 Wash Hose with Couplings
1 ⅝-inch Wire Rope 200 feet long
1 1-inch Manila Rope 150 feet long
1 ½-inch Manila Rope 110 feet long
1 Bag Grout
200 lbs. Chilled Shot
Necessary Pipe and Fittings for Drill, Boiler and Pump

1 Anvil
1 Combination Vise
1 Forge
1 Hot Chisel
1 Cold Chisel
1 Pair Smith's Tongs
1 Hammer
1 Monkey Wrench, 12 inches
1 Pair Sister Hooks
1 Hack Saw Frame
12 Hack Saws
12 Assorted Files
1 14-inch Sheave Pulley Block
1 Stillson Wrench, 10 inches
1 Stillson Wrench, 24 inches
2 Chain Pipe Wrenches, No. 12
2 Chain Pipe Wrenches, No. 14
2 Oilers



Standard 58-foot "Calyx" Tubular Steel Derrick

Class "BF-4" Power Driven

Size of hole bored	3⅝" to 8¾"
Diameter of core removed	2½" to 7½"
Depth capacity	1,000 to 1,500 ft.
Horse-power required to operate	11 to 15
Shipping Weight, complete (with 1,500 ft. drill rods)	18 500 lbs.

Regular Equipment

1 "BF" Rotating Device, complete with bed-plate.

1 No. 4 Friction Drum Hoist, with foot lever, brake ratchet and pawl and winch-head.

Drill, hoist and pump with pulleys, gears, etc., mounted on substantial frame with necessary connections for the drill pump and hoist.

NOTE—Where this machine is to be driven by electric motor it may be arranged for placing the motor on the same timber with the rest of the machine and direct-gearing it to the main shaft. This arrangement can be made where we furnish the motor of proper size and speed. If any other type, size, or speed of motor should be required and the motor is not to be placed on the same timber as the machine, the arrangement is the same as when a gasoline engine is used, driving the drill by belt.

1 4 x 4 Triplex Power Pump.

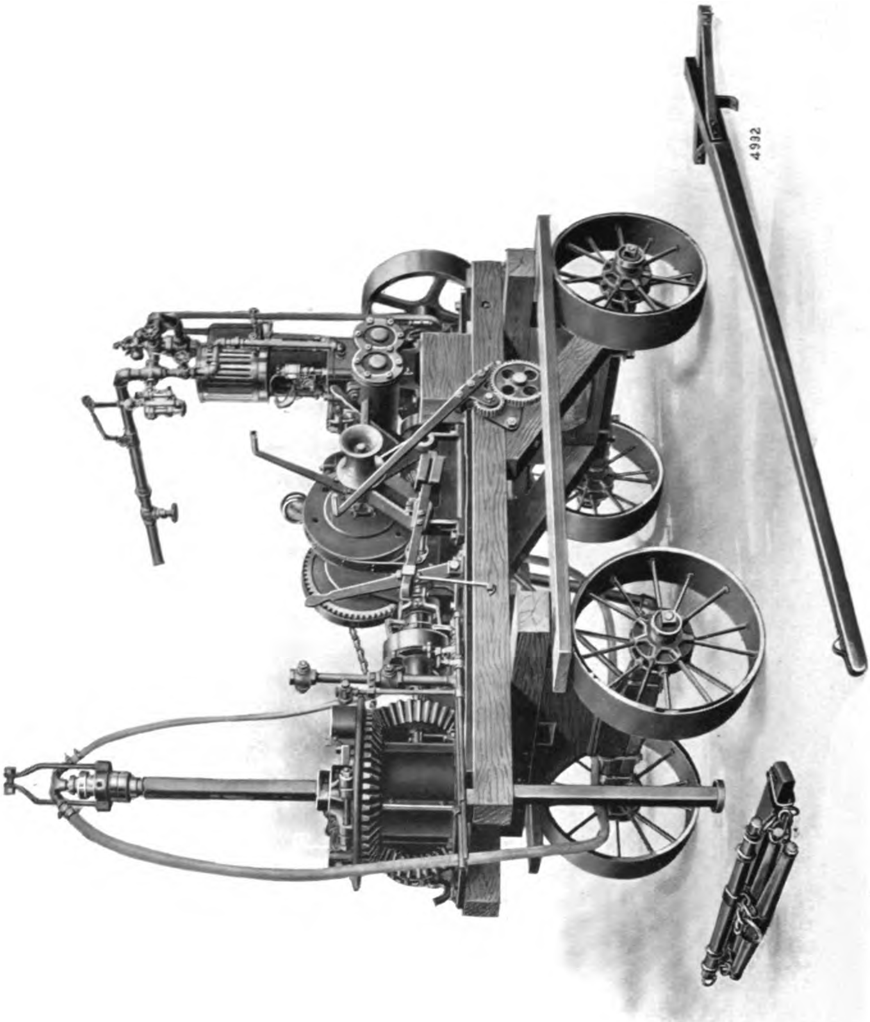
1 38-ft. Tubular Sectional Steel Derrick, complete with top and bottom timbers, sheaves and ladder.

1 Rotating Rod 7 feet long
1 Rotating Rod 15 feet long
1 Water Swivel
2 Hoisting Swivels
1 Safety Shackle
2 Davis Cutters
4 Shot Bits
1 Chopping Bit
1 Pair Casing Clamps
1 Core Barrel, short
1 Core Barrel, long
1 Core Barrel Plug
1 Calyx
Calyx Holder and Calyx Rod furnished with 4-inch tools and larger sizes
1 Drive Weight
Necessary Matching Couplings
1 Drill Rod 2 feet long with Coupling

2 Drill Rods each 5 feet long with Couplings
147 Drill Rods each 10 feet long with Couplings
2 Supporting Forks
1 Pressure Rope
1 Gouge
1 Flatter
1 Dressing Plate
2 Fishing Taps
1 Shot Feed complete
1 Shot Feed Hose with Couplings
1 Wash Hose with Couplings
1 ⅝-inch Wire Rope 200 feet long
1 1-inch Manila Rope 150 feet long
1 ½-inch Manila Rope 110 feet long
1 Bag Grout
200 lbs. Chilled Shot
Necessary Pipe and Fittings for Drill, Boiler and Pump

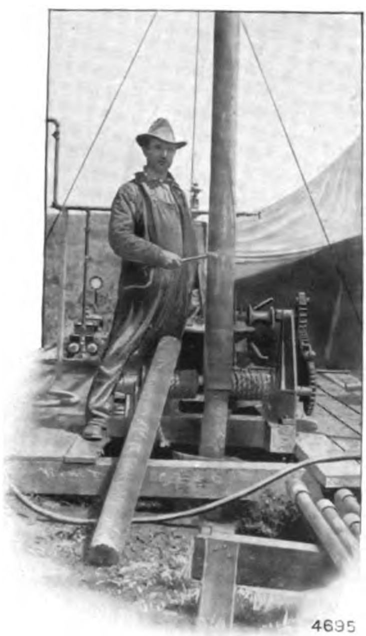
1 Anvil
1 Combination Vise
1 Forge
1 Hot Chisel
1 Cold Chisel
1 Pair Smith's Tongs
1 Hammer
1 Monkey Wrench, 12 inches
1 Pair Sister Hooks

1 Hack Saw Frame
12 Hack Saws
12 Assorted Files
1 14-inch Sheave Pulley Block
1 Stillson Wrench, 10 inches
1 Stillson Wrench, 24 inches
2 Chain Pipe Wrenches, No. 12
2 Chain Pipe Wrenches, No. 14
2 Oilers

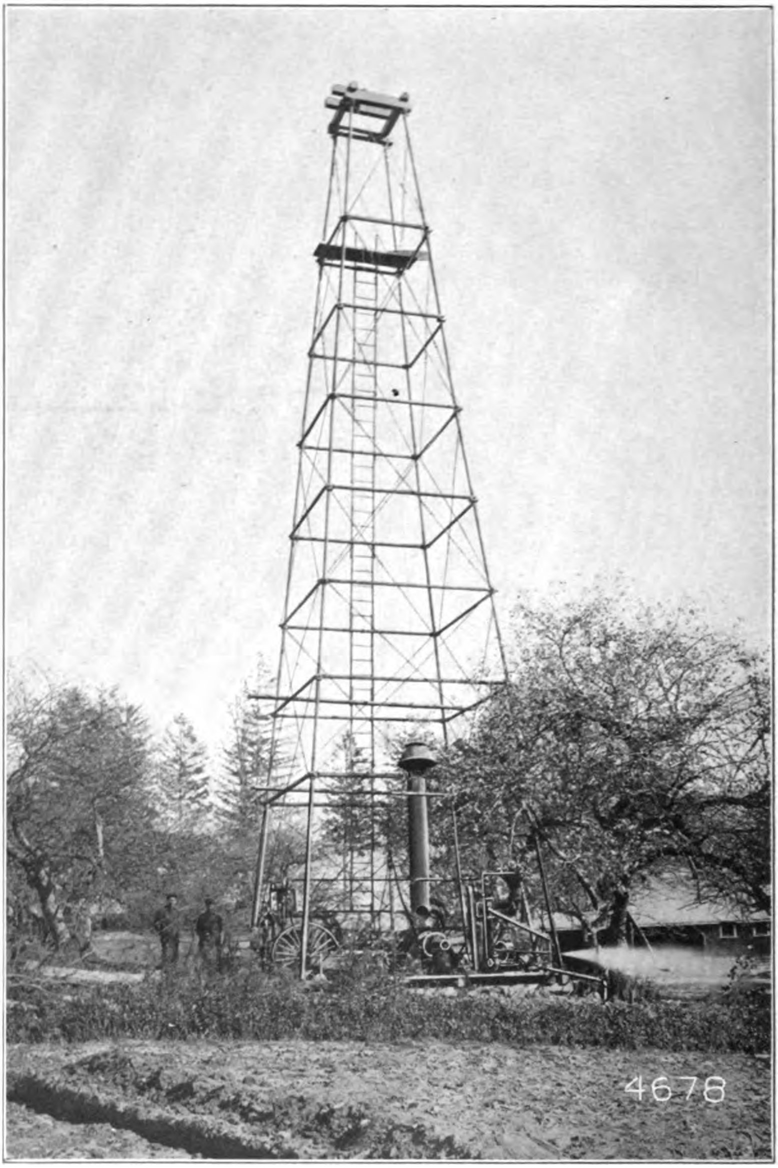


Portable Class "BF-1" Steam Driven "Calyx" Outfit

A 5-inch Core of Soft Coal Taken with a "Calyx" Outfit in Prospecting in Colorado



Prospecting in Colorado with the "Calyx" Drill; Removing the Core from the Core Barrel



A Class "BF-1" Calyx Outfit with Standard 58-Foot Steel Derrick

Ingersoll-Rand Co.

PNEUMATIC TOOL DEPARTMENT

"CROWN"

Pneumatic Hammers

Bulletin No. 2010

Labor-Saving Tools

Operated by Compressed Air

GUARANTEES

THE Ingersoll-Rand Company furnishes its "Crown" hammers under a standing absolute guarantee of interchangeability of parts.

The Ingersoll-Rand Company furthermore guarantees that such is the care exercised in the selection of materials, in the workmanship applied, and in the methods of production, that "Crown" hammers, under fair treatment and reasonable freedom from abuse, will give better results, with the minimum of delay and expense for repairs, for a longer period than those of any other manufacturer.

PATENTS

"Crown" Hammers are broadly covered by the following letters patent of the United States, and also by patents in foreign countries:

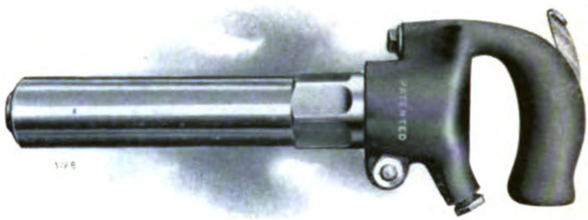
724,736 — April 7th, 1903

768,898 — August 30th, 1904

851,624 — April 23rd, 1907

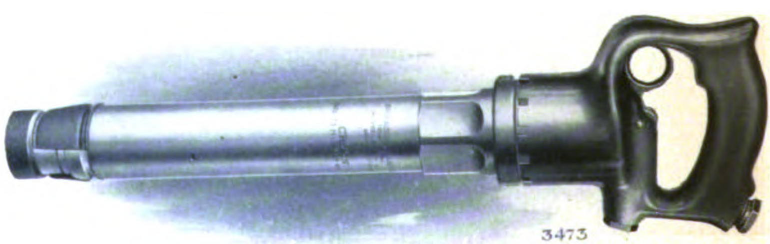
AN EXTRACT FROM THE PATENT CLAIMS

"The combination with a cylinder and a piston, of a valve having pressure-receiving surfaces to move it in opposite directions, means for intermittently applying pressure to one of such surfaces, and means for constantly applying a lower pressure to the other of such surfaces."



THE "CROWN" CHIPPING HAMMER

Made in five sizes suitable for all classes of chipping, calking, scaling and flue-beading. The larger sizes may be used for driving rivets of ½ inch diameter or smaller. Dimensions and weights are given on page 13.



THE "CROWN" RIVETING HAMMER

Made in four sizes suitable for driving rivets of ⅝ inch to 1½ inch in diameter. Dimensions and weights are given on page 13.

EXCLUSIVE FEATURES

A New Design — carrying with it unique advantages without departing from the standard and approved method of operation.

The Valve — a plain spool of hardened steel of one diameter, reversible, "fool-proof," and of the type approved in standard rock drill practise.

The Valve Box — a single piece of hardened and ground steel, with nothing to jar loose, shift or lose adjustment.

The Valve Movement — produced by unbalanced presures on a valve of uniform diameter — a feature covered by a basic-patent.

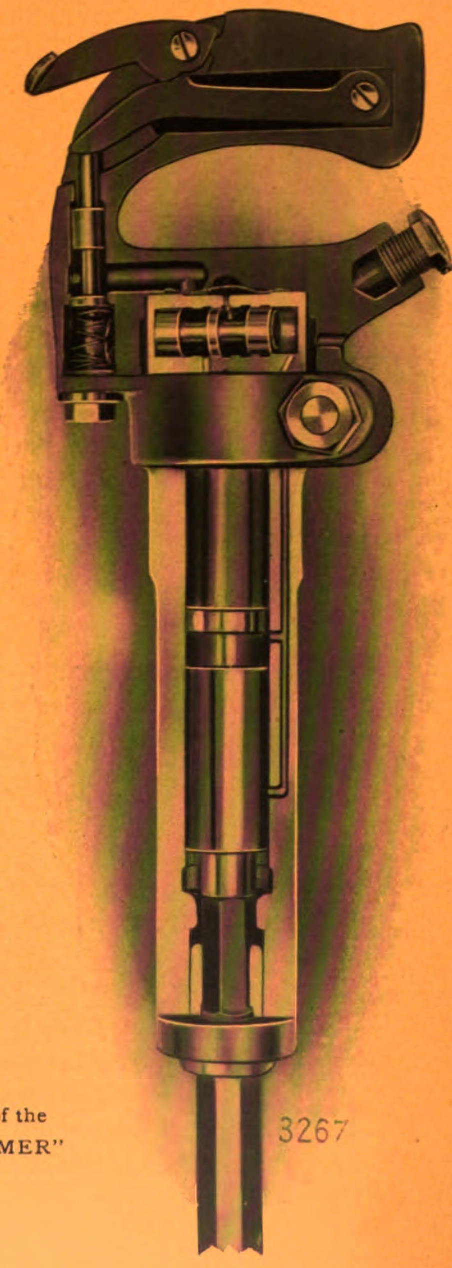
Cylinder and Piston — of hardened and ground steel — an exclusive feature resulting in the elimination of wear with consequent leakage and loss of power.

Blow — harder, sharper, and more rapid than that of any other hammer.

Capacity — greater than that of any other hammer of the same piston diameter and stroke, owing to the low friction of the moving parts.

Air Consumption — sustained over extended periods of operation, 20 to 30 percent less than that of any other hammer.

Repair Costs — lower than that of any other tool, owing to the simplicity of the design and to the hardening of all wearing parts.



Sectional View of the
"CROWN HAMMER"

CONSTRUCTION

THE VALVE

The valve is a plain spool shape, turned from selected steel, hardened and accurately ground to a uniform diameter. It is of the simplest and strongest form, identical in type with the spool valve used for years with such success in the most arduous conditions of rock drill service. Where the diameter is reduced to provide air passages, the reduction is secured by wide fillets which leave no opportunity for weak cross section or shrinkage flaws. It is extremely light, weighing less than an ounce, and in operation the vibration due to its movement is not perceptible. The simplicity of design and excellence of material sustain the Ingersoll-Rand guarantee against breakage in service of any "Crown" valve.

THE VALVE BOX

The valve box is a solid piece of hardened and ground steel of selected quality, bored transversely with a hole of uniform diameter, in which the valve travels. The air ports are simply drilled holes of ample diameter and of the least possible length. After the valve has been inserted in the valve box, the valve box sleeve, which is a ring of steel, is forced over the box and registered in position with a dowel pin, which prevents any possible shifting and consequent interference with port openings. The features to be noted in this connection are: First, the hardened valve travels in a hardened valve seat. There is practically no wear, and the action of the valve is unusually lively, owing to the fact that the friction between valve and seat is only the slight friction between two hardened

surfaces. Second, it is utterly impossible for any part of the valve box to jar loose, shift or lose adjustment. Third, with the valve in place, and the sleeve forced over the box, a safeguard is provided against the valve being tampered with. Should the action of the valve become faulty, the difficulty can be instantly corrected by substituting another valve box, when the original working conditions are restored.

3283-C

3277-C

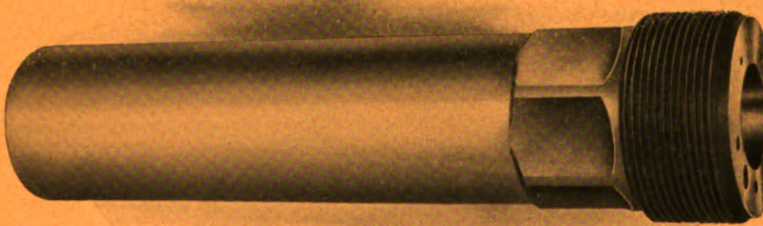
Valve Box Sleeve and Dowel Pin

THE VALVE MOVEMENT

The action of the valve in the "Crown" hammer is not to be confused with that of other hammers in which the movement is produced by equal pressures on differential areas. The construction in the latter case involves the use of a valve of two diameters; and it is commercially impossible to produce such accurate workmanship on such a valve, and on the seat which such a valve requires, that leakage is entirely avoided. In the "Crown" hammer the valve and seat are of uniform diameter and the process of grinding is one which produces absolute accuracy and a plug tight working fit is maintained indefinitely, owing to the fact that both surfaces are hardened. The movement of the valve is produced by unbalanced pressures on its two ends. On one end a pressure lower than the full working pressure is constantly maintained; on the other end the full working pressure is intermittently applied. This is the distinctive feature of the "Crown" hammer which is covered by basic patents. **It results in the utilization of the simplest, strongest and most efficient form of valve movement which is recognized as correct in pneumatic hammer design.**

THE CYLINDER

Another exclusive feature of the "Crown" hammer is the use of a cylinder with a hardened and ground bore. The material used is a steel of superior quality: and by a special process the interior or bore is hardened and ground, while the outside is left soft and tough.



3281

The hexagon section next to the handle provides a means for holding the hammer in a vise when taking apart for cleaning or adjustment. Another distinctive feature of this cylinder construction is the fact that ports are drilled from the inside of the bore. There are thus no plugged openings giving an opportunity for plugs to work loose, and leaving recesses in the cylinder bore to accumulate grit and score the surface of the piston. The cylinder bushing is accurately machined to receive the chisel shank or rivet set, and is forced into the front end of the cylinder.

3277-E

Cylinder Bushing

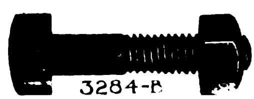
THE PISTON

The piston is a hardened and ground piece of selected steel of a shape proved by the widest experience to give the greatest durability and strength.

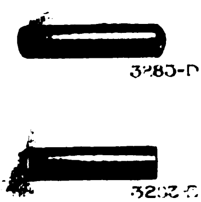
3277-D

THE HANDLE

The handle is of drop forged steel, colored by a special process instead of enameled. It screws over the cylinder and is secured by a locking bolt and lock nut which absolutely prevents any shifting. Ports in the handle are bored, are of unusually ample area, and are short as possible. The valve box sits in a recess in the handle and is clamped between handle and cylinder as the latter is screwed in place.



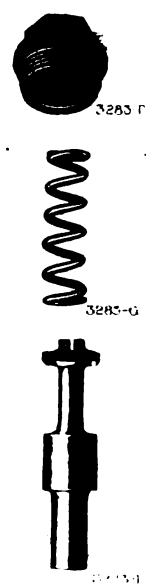
Handle, Nipple and Bolt



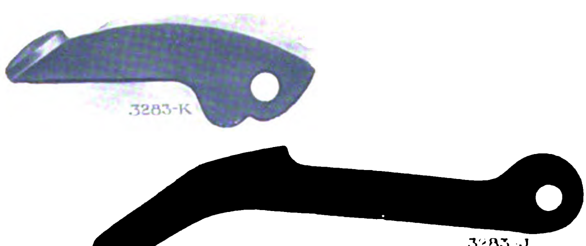
Dowel Pins for holding the Levers

THE THROTTLE AND ACCESSORIES

The controlling mechanism of the "Crown" hammer is made up of the usual throttle lever, piston valve, springs, etc. The use of this arrangement insures short, free ports, extreme simplicity and great endurance in service.



Piston Valve, Plug and Spring



The Throttle Levers

THE SCREEN

A unique feature of the "Crown" hammer is the use of a screen of usually large diameter. This is shown in its relative position to the other parts in the illustration on page 6. It is circular in shape and is inserted in a recess in the handle next to the valve box. It is thus entirely out of sight and out of reach of the operator who cannot remove it or injure it without entirely dismantling the hammer. Being of unusually large diameter it is much less likely to become clogged up with dirt, thus cutting down the air supply to the hammer. When it does become filled with dirt, it can easily be removed and cleaned by blowing a jet of air through it in the opposite direction from that in which the air usually passes through it.

Hose Nipple

THE AIR CONSUMPTION

The only true measure of air economy of a pneumatic tool is its air consumption as **sustained** over long periods of operation. Measured by this standard the air consumption of the "Crown" hammer is from 20 to 30 per cent. less than that of any other pneumatic hammer on the market. Air economy in the "Crown" hammer is due to two features distinctive of this tool. First, the clearance spaces are less than ever hitherto found in pneumatic tool practice. While the ports and air passages are unusually ample in area, they have been shortened up; and the small diameter of the valve is itself an important element in bringing down this loss which has hitherto been so large in other designs. Second, leakage is eliminated by the use of hardened surfaces throughout the tool

where wear would naturally occur, not only the valve and piston, but also the valve seat and cylinder bore being hardened. Examination of "Crown" hammers after months of operation has shown an air-tight working fit on both piston and valve, proving that the element of wear and consequent leakage has been removed.

CAPACITY

Exhaustive tests in actual service have shown that the "Crown" hammer has a larger capacity for work than any other hammer of the same size. This is due to the unmatched quality of the blow, which in turn is due to the elimination of friction, to the use of hardened surfaces and also to the direct air admission and exhaust ports which secure the full force of the air pressure on the piston from beginning to end of stroke, and the highest velocity of the striking piston.

REPAIR COST

The "Crown" hammer is the simplest pneumatic hammer made and has the least number of parts. The design of parts usually most delicate in a tool of this kind, is such as to give maximum strength and resistance. Hardened and ground wearing surfaces, already several times referred to, are another element in increasing the durability of "Crown" hammers to a point which has hitherto not been realized in pneumatic tool practice.

INTERCHANGEABILITY

Every part of "Crown" hammers is made to be absolutely interchangeable. Uniformity of dimension within the thousandth of an inch is maintained by the use of accurate limit gauges. Each part is carefully inspected as to quality and workmanship, and measured by this system of gauges. Uniformity of dimension and quality are thus assured and when a duplicate part is ordered it is absolutely certain to fit in place without any hand work or fitting.

"CROWN" HAMMERS

FOR

CHIPPING, CALKING, SCALING AND FLUE-BEADING

Telegraph Name	Style of Bushing	Size No.	Weight Pounds	Cubic Feet Free Air Per Minute		Piston Stroke Inches	Length Over All Inches	Size Hose Connections Pipe Thread Inches
				60 lb.	100 lb.			
Voragumflo...	Hexagon	55-H	13	14	24	5	15¾	¼
Voragumido..	Hexagon	54-H	12	13	22	4	14¾	¼
Voragumina..	Hexagon	53-H	11	12	20	3	13¾	¼
Voragumior ..	Hexagon	52-H	10	11	18	2	12¾	¼
Voragumis ...	Hexagon	51-H	9	10	17	1	11¾	¼
Voragumo....	Round	55-H	13	14	24	5	15¾	¼
Voragumoso..	Round	54-H	12	13	22	4	14¾	¼
Voragumpam.	Round	53-H	11	12	20	3	13¾	¼
Voragumpir ..	Round	52-H	10	11	18	2	12¾	¼
Voragun	Round	51-H	9	10	17	1	11¾	¼

SUITABLE FOR

55-H	Driving ½-inch diameter Hot Rivets. Extra Heavy Chipping and Calking.
54-H	Heavy Chipping and Calking. Riveting Light Tanks and Heavy Sheet Iron
53-H	General Chipping and Calking.
52-H	Light Chipping and Calking. Beading Flues and Scaling Castings.
51-H	Chipping and Calking Bath Tub and Range Boilers and other Light Work.

ACCESSORIES FURNISHED

55-H	Three Rivet Sets or Three Chisels.
All Other Sizes	Three Round or Hexagon Chisels.

"CROWN" HAMMERS

LONG STROKE RIVETERS

Telegraph Name	Size No.	Weight Pounds	Cubic Feet Free Air Per Minute		Piston Stroke Inches	Length Over All Inches	Size Hose Connections Pipe Thread Inches
			60 lbs.	100 lbs			
Voragurgam..	73-H	22½	27	50	10	22¼	⅜
Voragurian...	72-H	22	25	49	9	21¼	⅜
Voragurios ...	71-H	21	24	45	8	20¼	⅜
Voraguriza ...	70-H	19	22	42	6	18¼	⅜

SUITABLE FOR

73-H	Driving Rivets—1⅜-inch diameter and less
72-H	Driving Rivets—1¼-inch diameter and less
71-H	Driving Rivets— 1 inch diameter and less
70-H	Driving Rivets—¾-inch diameter and less

ACCESSORIES FURNISHED

All Sizes	Three Rivet Sets.

THE OPERATION

The operation of the "Crown" hammer will be understood by reference to the accompanying sectional diagram.

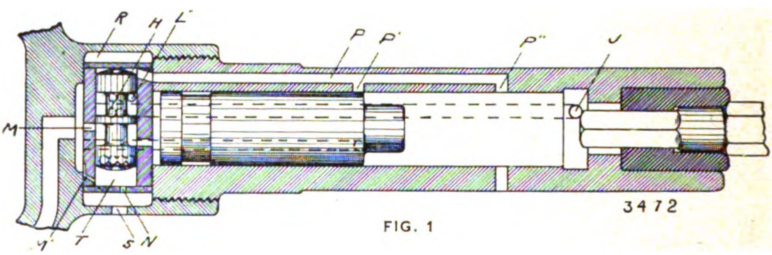


FIG. 1

The ports being in the position shown in Fig. 1, air entering through the port V in the handle, passes through the ports M and M' into the valve box. Part of the air which enters through the port M' escapes through port N, causing the air pressure in the chamber T in the valve box to be reduced below the working pressure in the hammer. This reduces pressure in the chamber T, holds the valve in the position shown, and allows the air entering the ports M to pass around the valve D, through the ports K into the cylinder, forcing the piston forward to the position shown in Fig. 2.

Air from the front end of the cylinder exhausts through the ports X and ports J, H, L' and the exhaust space R, during the forward stroke of the piston.

When the piston reaches the end of its stroke, it allows the live air to pass from the port Y around the groove W in the piston, and through the ports P and P' to the chamber T' in the valve box. This pressure being greater than the pressure in the chamber T forces the valve to the position shown in Fig. 2.

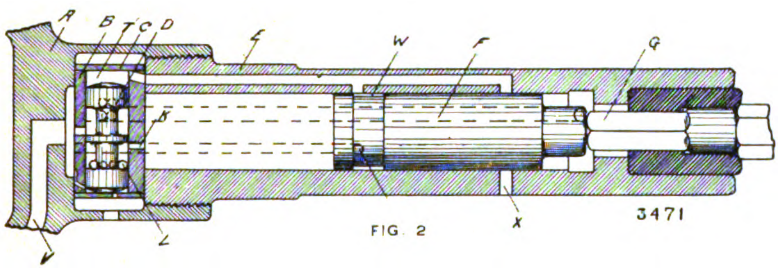


FIG. 2

Air coming through the ports M now passes through the ports H and J to the front end of cylinder, forcing the piston backward to the position shown in Fig. 1. During this backward travel the pressure in the rear end of the cylinder is exhausted through the ports K and L and the exhaust space R.

When the piston in its backward travel uncovers the port P" and port X, it allows all the pressure in the port P and the front end of the cylinder to escape. This removes the pressure from the chamber T' in the valve box, causing the valve to resume the position shown in Fig. 1, due to the action of the constant pressure in the chamber T.

The ports are now in their original position, the cycle of operation is completed and ready for repetition on the next stroke.

THE CARE OF "CROWN" HAMMERS

It is doubtful if any piece of machinery pays greater profit on its original cost than a pneumatic hammer if kept in good working condition. It is also doubtful if any piece of high speed, high grade machinery is so much abused by neglect as to its cleaning and oiling.

It is essential to the good working and durability of all pneumatic hammers that they be kept **clean and well oiled.** This should not be delayed until the tool stops working on account of dirt, rust or gummed oil. Clean thoroughly with kerosene or benzine before oiling, when ready to put the tool in operation. Do this by immersing the entire tool in kerosene, or better still, by keeping the tools immersed in kerosene when not in use.

All hammers should be oiled through the hose nipple on the end of the handle before being put in service. Only good, light-body oil should be used. Sewing-machine oil is good, but what is still better is "**Sprayoleum,**" an oil manufactured especially for the Ingersoll-Rand Company for use with pneumatic tools. Heavy oils should be avoided as they gum up and cause the tool to work sluggishly, with consequent loss of power.

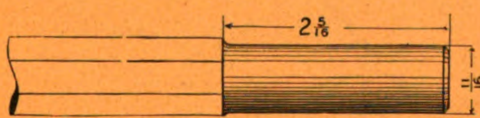
It will handsomely repay any user of pneumatic hammers to keep the inside of the tools as clean and well oiled as a sportsman does his gun.

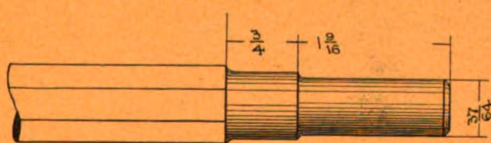
The construction of "Crown" hammers is such that none of the parts will break under service, and the tools will always work well and maintain their efficiency for an indefinite length of time, if they are kept clean and well oiled.

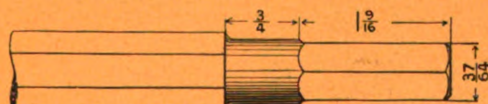
CHISEL AND RIVET SET SHANKS

Each new hammer, when shipped, has three chisels or three rivet sets, depending on whether it is a chipping or riveting hammer.

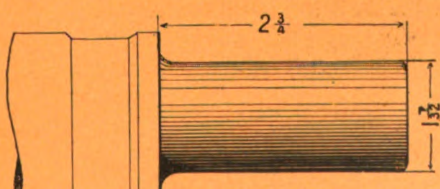
The shanks on these blanks are made to fit snugly in the bushing in the end of the tool, and it is important that a reasonably close fit be maintained, as otherwise air leaks past the shank and







13



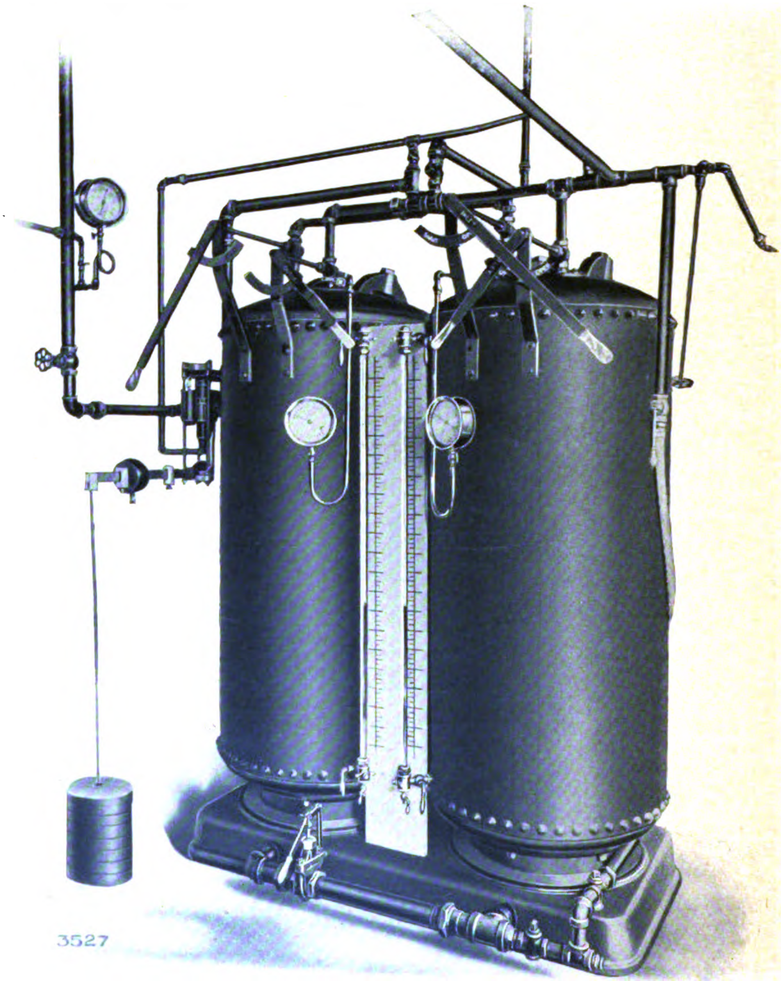
14

the tool will not work to best advantage. The shank dimensions given on the line drawings herewith, are standard, and should be used in re-forming old tools or making new ones.

DISPLACEMENT AIR METER

FOR MEASURING

THE AIR CONSUMPTION OF PNEUMATIC TOOLS



During the past twelve years the Ingersoll-Rand Company has used large numbers of pneumatic tools of all types in its shops and foundries. Recognizing that the air consumption of such tools as sustained over an extended period of use is an important factor in securing the best results from them as cost-reducers, the Company has from time to time made exhaustive tests in order to secure the benefit of the best tools obtainable.

It is evident that the **sustained efficiency** of a tool depends upon the wear-resisting qualities of its moving parts. This wear affects not only the air consumption of the tool, but also its power and capacity. Excessive wear means heavy leakage, with waste of air and loss of power. Experience has demonstrated that most pneumatic tools, after being in service only a short time, suffer an increase in their air consumption with a falling off in their power due to the leakage arising from the wear of soft materials in valves, valve boxes, pistons and cylinders.

In order to prove just how much this loss of power amounts to, and to assist in guarding against it in its own line of pneumatic tools, the Ingersoll-Rand Company devised and installed in the testing room of its Pneumatic Tool Department the water displacement air meter illustrated on the opposite page. Without going into details, it will be enough to say that this device accurately measures the volume of air used by any tool in doing a certain amount of work, the air volume supplied to it displacing from one tank to another its exact equivalent volume of water. This is the only **positive** means of metering the air consumption of any tool.

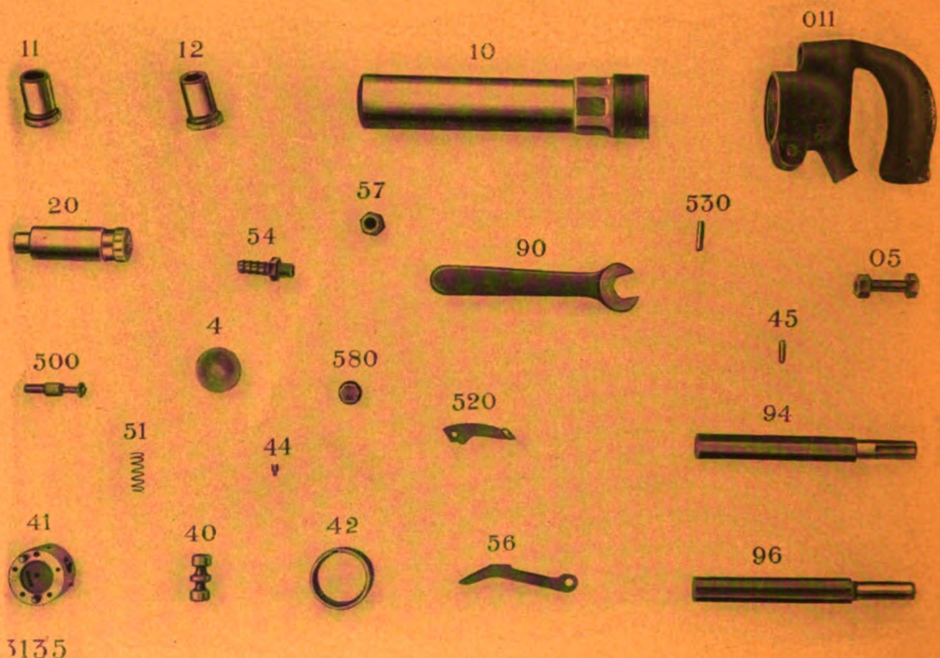
The figures on air consumption of "Crown" Hammers given on page 14 were found by means of this meter. They are therefore absolutely correct. The high air economy of these tools is due to the fact that valve, valve box, piston and cylinder are all made of selected steel **carefully hardened and ground.** Wear is thus practically eliminated and the air-tight fit of valve and piston—the only two moving parts—is maintained indefinitely. This is a refinement found in "Crown" Hammers exclusively and is the basis of the claim for these tools of **the highest sustained** power and economy.

The Ingersoll-Rand Company claims as a result of tests of its own and of other makes, new, worn and old, that its line of pneumatic tools are the most economical in net cost of work done, not as a matter alone of original performance, but for their lifetime, and this claim is backed up by practical results secured in its several large plants where air tools are used on an extensive scale.

"CROWN" HAMMERS

CHIPPING HAMMERS

Sizes: 51-H, 52-H, 53-H, 54-H and 55-H.



DUPLICATE PART LIST

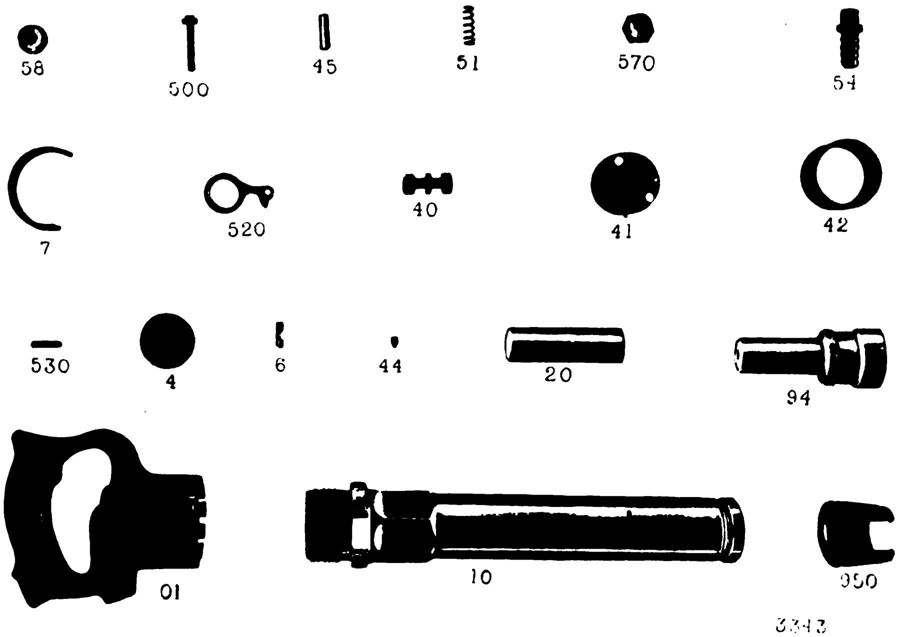
Telegraph Name	Symbol and Number of Part	Name of Part	Telegraph Name	Symbol and Number of Part	Name of Part
Voragundio..	3H-011	Handle	Voraguptam .	51H-44	Valve Box Sleeve Dowel
Voragunes...	3H-4	Strainer	Voraguptio ..	51H-45	Valve Box Dowel
Voragungis ..	3H-05	Handle Clamp Bolt	Voraguquem.	3H-500	Throttle Valve
Voragunhem.	51H-10	Cylinder	Voragura....	3H-51	Throttle Valve Spring
Voragunho ..	52H-10	Cylinder	Voraguraca..	3H-520	Throttle Lever
Voragunico..	53H-10	Cylinder	Voragurano..	9H-530	Throttle Lever Pin
Voragunta...	54H-10	Cylinder	Voraguraux .	3H-54	Hose Nipple
Voragunzia..	55H-10	Cylinder	Voragurbem .	3H-56	Lever
Voraguoco...	51H-11	Cylinder Bushing, Round	Voragurcas ..	3H-570	Nipple
Voraguore ...	51H-12	Cylinder Bushing, Hexagon	Voragurdir ..	3H-580	Screw Plug
Voraguosa ...	3H-20	Piston	Voragurent ..	51H-90	Clamp Bolt Wrench
Voragupalo ..	....	Valve Box and Valve Complete, consisting of Parts 40, 41, 42, 44 and 45.	Voragurero ..	3H-94	Chisel Blank, Hexagon
Voragupebo .	51H-40	Valve	Voragureur ..	3H-96	Chisel Blank, Round
Voragupera..	51H-41	Valve Box	Voragurfal ..	3H-98	Chisel Blank, Differential
Voraguphea .	51H-42	Valve Box Sleeve			

NOTE—Any part of any size Chipping Hammer is interchangeable with the like part of any other Chipping Hammer, excepting the Cylinder—Part No. 10.

"CROWN" HAMMERS

RIVETING HAMMERS

Sizes: 70-H, 71-H, 72-H and 73-H



DUPLICATE PART LIST

Telegraph Name	Symbol and Number of Part	Name of Part	Telegraph Name	Symbol and Number of Part	Name of Part
Voragurreo ..	9H–01	Handle	Voragutoir ..	51H–44	Valve Box Sleeve Dowel
Voragurror ..	3HD–4	Strainer	Voraguteba ..	70H–45	Valve Box Dowel
Voraguscar ..	3H–6	Key	Voragutuum .	9H–500	Throttle Valve
Voragusino ..	9H–7	Key Spring	Voraguunt...	3H–51	Throttle Valve Spring
Voragusite...	70H–10	Cylinder	Voraguvela ..	70H–520	Throttle Trigger
Voragussas ..	71H–10	Cylinder	Voraguviem .	9H–530	Throttle Valve Trigger Pin
Voragussim..	72H–10	Cylinder	Voraguvion ..	9H–570	Nipple
Voragustez ..	73H–10	Cylinder	Voraguxio ...	3H–58	Screw Plug
Voragustro ..	9H–20	Piston	Voraguzafa ..	9H–94	Rivet Set Blank
Voragutega ..	....	Valve Box and Valve complete, consisting of Parts 40, 41, 42, 44 and 45	Voraguzar ...	9H–94A	Rivet Set Finished
Voragutelo ..	70H–40	Valve	Voraguzza ...	9H–950	Rivet Set Spring
Voragutere ..	70H–41	Valve Box			
Voragutiam .	70H–42	Valve Box Sleeve			

NOTE—Any part of any size Riveting Hammer is interchangeable with the like part of any other Riveting Hammer, excepting the cylinder—Part No. 10.

Chipping a Cylinder with "Crown" Hammers.

Ingersoll-Rand Publications

Air Compressors.

36.	Catalog—Ingersoll-Sergeant Air and Gas Compressors.
R-37.	Catalog—Rand Air and Gas Compressors.
35-D.	Leaflet—Ingersoll-Rand Air Compressors.
340.	Booklet—Blue Book of Air Compressors.
X-36.	Catalog—"Imperial" Type Ten Air Compressors.
XI-36.	Catalog—"Imperial" Type Eleven Air Compressors.
H-36.	Catalog—Class "H" Air Compressors.

Rock Excavation.

46.	Catalog—Rand Rock Drills and Mountings.
45-B.	Catalog—Ingersoll-Sergeant Rock Drills.
45-A.	Leaflet—Ingersoll-Rand Rock Drills.
60.	Catalog—Stone Channeling Machines.
60-A.	Leaflet—Quarry Machinery.
322.	Pamphlet—The "Broncho" Channeler.
241.	Booklet—Driving the New York Subway.
346.	Pamphlet—The Central Air Plant.
2009.	Bulletin—The "Little Imp" Hammer Drill.
2011.	Bulletin—The "Little Jap" Hammer Drill.

Core Drilling.

91.	Catalog—The Davis Calyx Diamondless Drill.
91A.	Leaflet— " " " " "

Coal Mining.

52.	Catalog—Coal Mining Machinery.
52-A.	Leaflet—Coal Mining Machinery.
353.	Pamphlet—The "Radialaxe" Coal Cutter.

Air Lift.

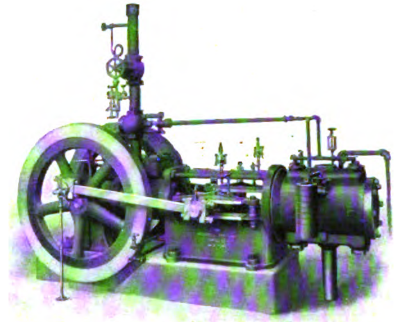
R-12.	Catalog—Pumping by Compressed Air.
73.	Catalog—Lifting Water by Compressed Air.
74-A.	Booklet—Pneumatic Pumping.

Pneumatic Tools.

6.	Catalog—Haeseler "Axial Valve" Air Hammers.
2004.	Bulletin—Stone Working Tools.
2006.	Bulletin—"Imperial" Pneumatic Hammers.
2007.	Bulletin—"Imperial" Pneumatic Drills.
2008.	Bulletin—"Imperial" Air Hoists and Stationary Motors.
6-A.	Leaflet—Ingersoll-Rand Pneumatic Tools.

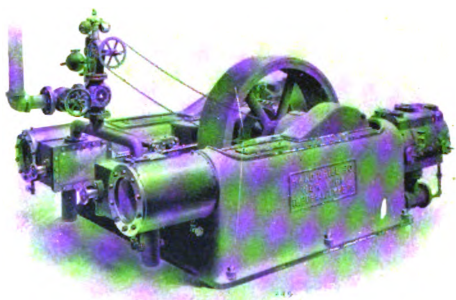
Complete Air Installations

Bench Sand Rammer

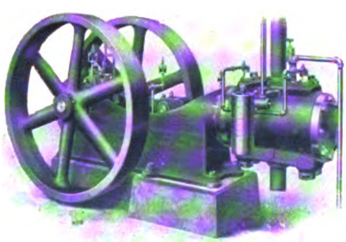


A straight line steam driven Air Compressor of small or medium capacity. High efficiency with minimum attention

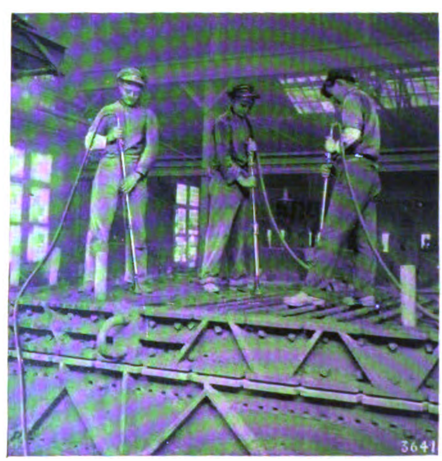
One of the "Imperial" Type Ten Compressors



Steam or power driven. All pressures and all capacities



A straight line power driven Air Compressor of small or medium capacity. For shops and factories when surplus power is available



Floor Sand Rammer

THE POINT & DAVIS CO. 225 FOURTH AVE., NEW YORK

"IMPERIAL" TYPE "E" PNEUMATIC HAMMERS

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 8003 May, 1910

"Imperial" Riveting Hammer on Building Construction

"The purposes to which these (pneumatic) hammers may be applied are many. . . . To whatever purpose, however, the hammer may be put, it is necessary to remember that proper efficiency can only be obtained by selecting hammers of suitable weight and stroke for each class of work. No tool can be adapted to all classes of work. It is not uncommon to find operators attaching blame to a tool on account of its failing to successfully do its work, when the real cause of failure is due to the application of the wrong tool. . . In the author's opinion, it is very desirable that the useful capacity of any machine shall be carefully determined and not exceeded, and, as in other classes of machines, it is better to use two or more machines of different sizes than to apply one for doing work beyond its range."

Ewart C. Amos, in Paper before
Institution of Mechanical Engineers.

In the pneumatic tool world the name "Imperial" has come to be synonymous with reliability and satisfactory performance. The improved Type "E" Imperial Pneumatic Hammers to which this Bulletin is devoted, represent tools which have been on the market for several years and from which all weaknesses have been eliminated. The new improvements have increased the power, speed and durability of these machines, at the same time practically doing away with all vibration.

Today "Imperial" Hammers are made as well as it is possible to make a tool, in shops equipped with every up-to-date device for producing fine workmanship and specially treated materials of the highest grade.

The fact that "Imperial" Hammers are built by the largest and most responsible Company in the pneumatic tool field is a guarantee that the tools will realize all claims which are made for them.

"Imperial" Pneumatic Hammers are reliable and efficient, and economical in the use of air. They can always be depended upon to do the work for which they are designed at the lowest cost. They operate most successfully under air pressures from 80 to 100 lbs., and under these conditions strike hard, positive and rapid blows of most effective quality. As the piston cushions on live air there is practically no vibration and no annoyance whatever to the operator.

The valve movement of "Imperial" Hammers is extremely simple, consisting of a solid cup-shaped valve moving always in the same direction as the piston. The piston on the return stroke recesses within the cup-shaped valve, giving a longer piston stroke with a shorter cylinder than is possible in other types. This valve movement is positive and entirely free from the "fluttering" which is so prominent a fault in many other types.

All parts of these hammers are built on the interchangeable system and are guaranteed to fit. Any ordinary mechanic can readily make such repairs as are usually required. The perfection of design, the efficiency of the port lay-out, the quality of material and workmanship, and the system under which they are assembled and constructed, enables the Company to offer "Imperial" Hammers as superior to any other tools for like service on the market; and their expense for repairs will be only a nominal item under proper care.

Table of Dimensions and Capacities of Standard Type "E" Chipping and Riveting Hammers

Type "E" Scaling Hammers

Telegraph Name	Size No.	Weight Pounds	Cubic Ft. Free Air Per Min. at 80 lbs. Pressure	Piston Stroke Inches	Length Over All Inches	Suitable for	Equipment
Hardler	0	5½	13½	1¼	9½	Nos. 0 and 00 Very Light Chipping or Calking; Scaling Paint or Rust on Iron; for Heavy Cutting or Roughing on Stone.	SCALING AND CHIPPING HAMMERS 1 Hose Nipple 1 Wrench 1 Strainer 3 Chisel Blanks with shanks as ordered
Hardiesse	00	6	11	1¾	10½		

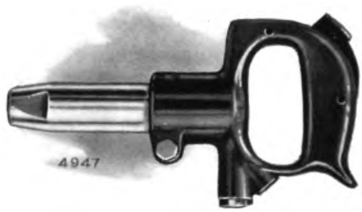
Type "E" Chippers

Telegraph Name	Style of Bushing	Size No.	Weight Pounds	Cubic Ft. Free Air Per Min. at 80 lbs. Pressure	Piston Stroke Inches	Length Over All Inches	Suitable for	Equipment
Hardde	Hexagon Bushing	1	11½	18¾	1½	11	No. 1 Chipping and Calking Bath Tubs and Range Boilers and other Light Work No. 2 Light Chipping and Calking Beading Flues and Scaling Castings No. 3 General Chipping and Calking No. 4 Heavy Chipping and Calking No. 5 Extra Heavy Chipping and Calking	SCALING AND CHIPPING HAMMERS 1 Hose Nipple 1 Wrench 1 Strainer 3 Chisel Blanks with shanks as ordered
Harddraven	" "	2	12¼	18	2	12		
Hardebol	" "	3	13½	19½	3	14		
Hardecanut	" "	4	15	19½	4	16		
Hardening	" "	5	16½	18½	5	17½		
Hardesvogt	Round "	1	11½	18¾	1½	11		
Hardgeel	" "	2	12¼	18	2	12		
Hardhandig	" "	3	13½	19½	3	14		
Hardhead	" "	4	15	19½	4	16		
Hardhoorig	" "	5	16½	18½	5	17½		

Type "E" Riveters

Telegraph Name	Size No.	Weight Pounds	Cubic Ft. Free Air Per Min. at 80 lbs. Pressure	Piston Stroke Inches	Length Over All Inches	Style — Long Stroke Riveting Hammers Suitable for	Equipment
Hardigheid	40	15	19½	4	16	No. 40 Driving Rivets, ½" Diameter and less. No. 50 Driving Rivets, ¾" Diameter and less. No. 66 Driving Rivets, ⅞" Diameter and less. No. 99 Driving Rivets, 1¼" Diameter and less.	RIVETING HAMMERS 1 Hose Nipple 1 Strainer 1 Wrench 3 Rivet Sets, blank or finished 1 Rivet Set Clip or Spring
Hardihood	50	16½	18½	5	17½		
Hardiment	66	20	30	6	17¾		
Hardkelk	99	23	30½	9	20¾		

"Imperial" Type "E" Scaling Hammers



"Imperial" Type "E" Scaling Hammer

Size "O"

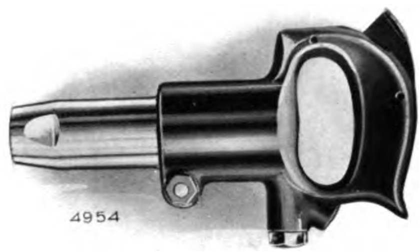
For very light chipping or calking; scaling paint or rust on iron; heavy cutting or roughing on stone.

"Imperial" Type "E" Scaling Hammer

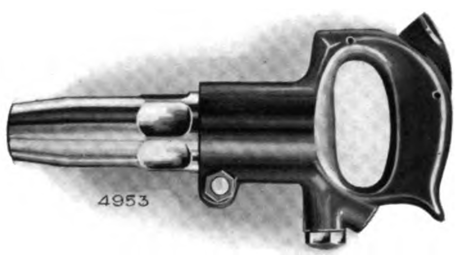
Size "OO"

For very light chipping or calking; scaling paint or rust on iron; heavy cutting or roughing on stone.

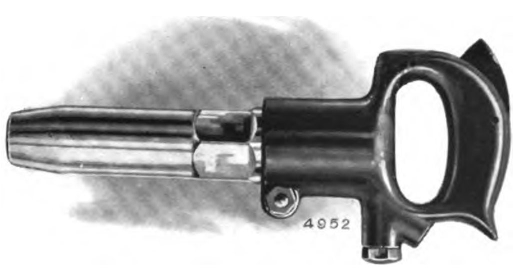
"Imperial" Type "E" Chipping Hammers



"Imperial" Type "E" Chipping Hammer. No. 1
For chipping and calking bath tubs, range boilers and other light work.



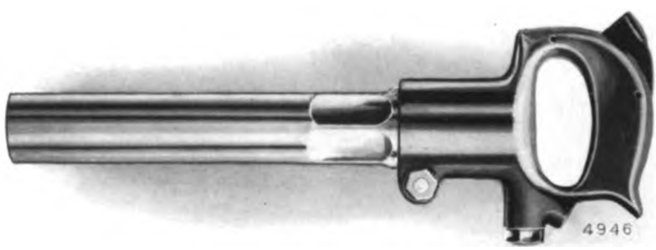
"Imperial" Type "E" Chipping Hammer. No. 2
For light chipping and calking; beading flues and scaling castings.



"Imperial" Type "E" Chipping Hammer. No. 3
For general chipping and calking.

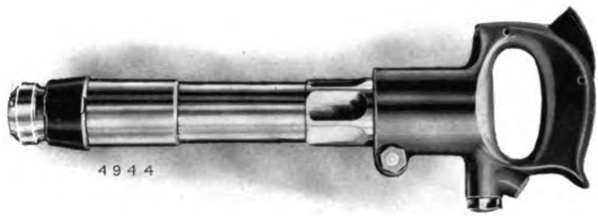
"Imperial" Type "E" Chipping Hammers

"Imperial" Type "E" Chipping Hammer. No. 4
For heavy chipping and calking.

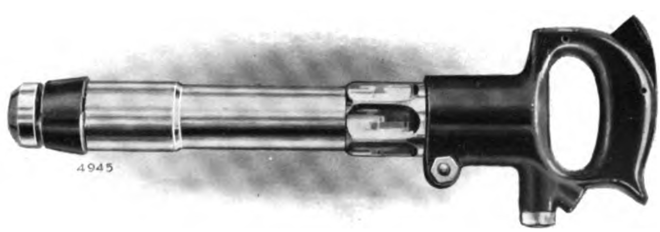


"Imperial" Type "E" Chipping Hammer. No. 5
For extra heavy chipping and calking.

"Imperial" Type "E" Riveting Hammers

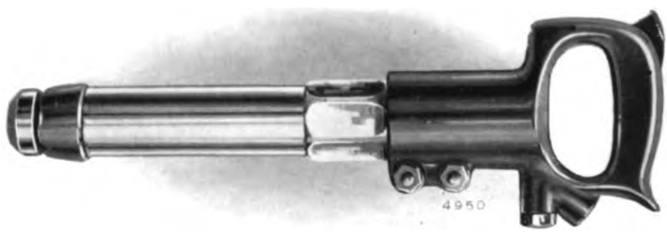


"Imperial" Type "E" Riveting Hammer. No. 40
For driving rivets up to ½-inch diameter.

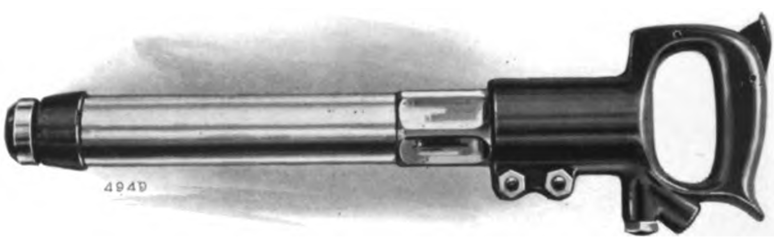


"Imperial" Type "E" Riveting Hammer. No. 50
For driving rivets up to ¾-inch diameter.

"Imperial" Type "E" Riveting Hammers



"Imperial" Type "E" Riveting Hammer. No. 66
For driving rivets up to ⅞-inch diameter.



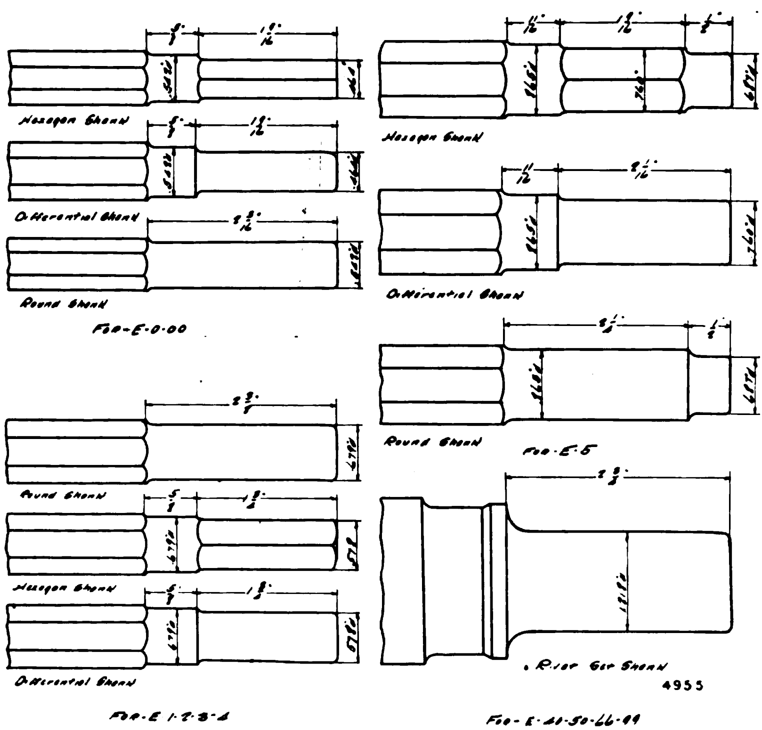
"Imperial" Type "E" Riveting Hammer. No. 99
For driving rivets up to 1¼-inch diameter.

Chisel and Rivet Set Shanks

Each new hammer, when shipped, has three chisels or three rivet sets, depending on whether it is a chipping or riveting hammer.

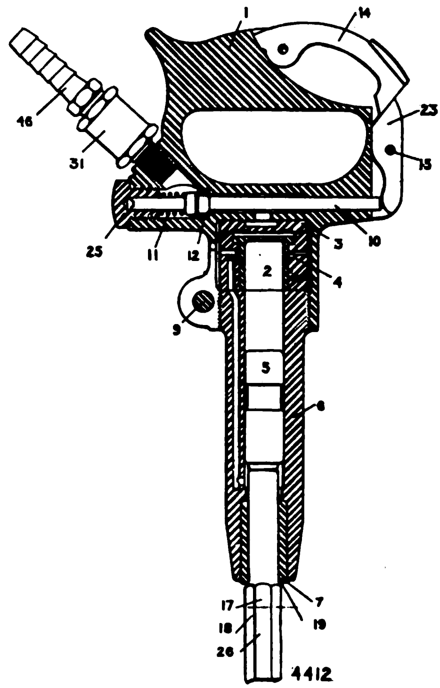
The shanks of these blanks are made to snugly fit the bushing in the end of the tool, and it is important that a reasonably close fit be maintained, as otherwise air leaks past the shank, and the tool will not work to best advantage.

The shank dimensions given on cut herewith are standard, and should be used in re-forming old or making new tools.



Duplicate Part List

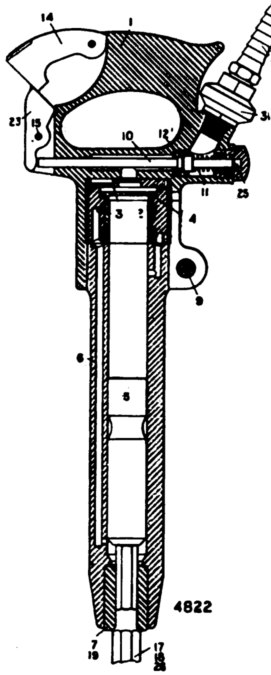
"Imperial" Scaling Hammers. Sizes E-o and E-oo



Telegraph Name	Part No.	Symbol	Name of Part
Hedymeles	1	E0	Handle Bare
Hedyphane	9	E0	Handle Clamp Bolt and Nut
Hedypnois	10	E0	Throttle Valve
Hedysare	11	B1	Throttle Valve Spring
Hedysarum	12	E0	Throttle Valve Seat
Hedysma	14	E0	Throttle Lever
Hedysmata	15	B1	Throttle Lever Pin (2)
Hedysmatis	23	E0	Intermediate Lever
Heedfully	25	E0	Throttle Valve Cap
Heedily	....	....	Handle, Complete
Heediness	2	E0	Valve
Heedlessly	3	E0	Valve Box Cap
Heehawed	4	E0	Valve Box
Heehawing	....	....	Valve Box, Complete parts 2, 3 and 4
Heelemaal	5	E0	Piston No. 0
Heelgoed	5	E00	Piston No. 00
Heelhout	6	E0	Cylinder No. 0
Heeling	6	E00	Cylinder No. 00
Heelkracht	7	E0	Hexagon Cylinder Bushing
Heelkruid	17	E0	Round Chisel Blank
Heelkundig	18	E0	Hexagon Chisel Blank
Heelshuldos	19	E0	Round Cylinder Bushing
Heelster	26	E0	Differential Chisel Blank
Heelwortel	27	E0	Wrench
Heemer	31	E0	Strainer, Complete
Heempjes	46	A1	Hose Nipple

Duplicate Part List

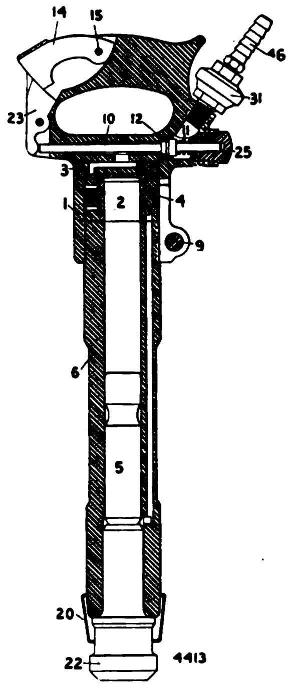
"Imperial" Chipping Hammers. E-1, E-2, E-3, E-4 and E-5



Telegraph Name	Part No.	Symbol	Name of Part
Harpooning	1	E3	Handle Bare
Harpress	9	E3	Handle Clamp Bolt and Nut
Harpsichon	10	B4	Throttle Valve
Harpsnaar	11	B1	Throttle Valve Spring
Harpspel	12	B4	Throttle Valve Seat
Harpster	14	E3	Throttle Lever
Harptoon	15	B1	Throttle Lever Pin (2)
Harpuizen	23	E3	Intermediate Lever
Harpule	25	B1	Throttle Valve Cap
Harquebuss			Handle Complete
Harraging	2	E3	Valve
Harrender	3	E3	Valve Box Cap
Harriman	4	E3	Valve Box, Hammers Nos. 1, 2, 3, 4, 5
Harriveau			Valve Box Complete, Parts 2, 3 and 4
Harsachtig	5	E1	Piston No. 1
Harsboom	5	E2	Piston No. 2
Harschheit	5	E3	Piston No. 3
Harsgom	5	E4	Piston Nos. 4, 5
Harshened	6	E1	Cylinder No. 1
Harshening	6	E2	Cylinder No. 2
Harshly	6	E3	Cylinder No. 3
Harshness	6	E4	Cylinder No. 4
Harskoek	6	E5	Cylinder No. 5
Harskoeken	7	B1	Hexagon Cyl. Bushing Nos. 1, 2, 3, 4
Harsolie	7	B5	Hexagon Cyl. Bushing No. 5
Harsplant	17	B1	Round Chisel Blank Nos. 1, 2, 3, 4
Harsthorn	17	B5	Round Chisel Blank No. 5
Harstoel	18	B1	Hexagon Chisel Blank Nos. 1, 2, 3, 4
Harsvernis	18	B5	Hexagon Chisel Blank No. 5
Harswinde	19	B1	Round Cyl. Bushing Nos. 1, 2, 3, 4
Harszalf	19	B5	Round Cyl. Bushing No. 5
Harszeep	26	B1	Differential Chisel Blank Nos. 1, 2, 3, 4
Hartabas	26	B5	Differential Chisel Blank No. 5
Hartaderen	27	B1	Wrench
Hartais	31	E66	Strainer Complete
Hartaknud	38	B1	Octagon Chisel Blank Nos. 1, 2, 3, 4
Hartall	39	B1	Octagon Cyl. Bushing Nos. 1, 2, 3, 4
Hartaramos	46	A1	Hose Nipple

Duplicate Part List

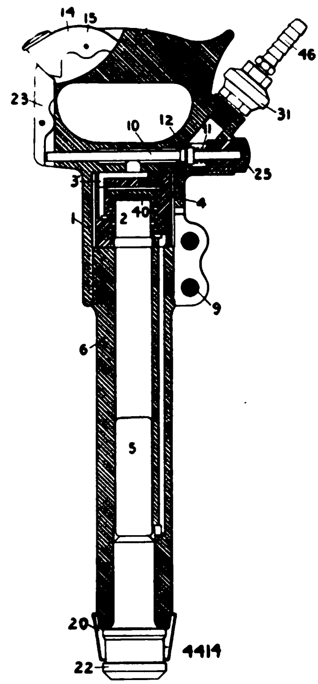
"Imperial" Riveting Hammers. E-40 and E-50



Telegraph Name	Part No.	Symbol	Name of Part
Hartaran....................	1	E3	Handle Bare
Hartazgo....................	9	E3	Handle Clamp Bolt and Nut
Hartebloed..................	10	B4	Throttle Valve
Hartedief...................	11	B1	Throttle Valve Spring
Hartelijk...................	12	B4	Throttle Valve Seat
Harteloos...................	14	E3	Throttle Lever
Hartelust...................	15	B1	Throttle Lever Pin (2)
Hartemos....................	23	E3	Intermediate Lever
Hartevlies..................	25	B1	Throttle Valve Cap
Hartewee....................	....	....	Handle Complete
Hartewond...................	2	E3	Valve
Hartfutter..................	3	E3	Valve Box Cap
Harthaut....................	4	E3	Valve Box
Hartheide...................	....	....	Valve Box Complete Nos. 2, 3 and 4
Hartine.....................	5	E66	Piston
Hartjes.....................	6	E40	Cylinder No. 40
Hartjesdag..................	6	E50	Cylinder No. 50
Hartkelch...................	20	B66	Rivet Set Spring
Hartklep....................	22	B66	Rivet Set Blank
Hartklier...................	22A	B66	Rivet Set Finished
Hartkopf....................	27	B1	Wrench
Hartkorn....................	31	E66	Strainer Complete
Hartkruid...................	46	A1	Hose Nipple

Duplicate Part List

"Imperial" Riveting Hammers. E-66 and E-99



Telegraph Name	Part No.	Symbol	Name of Part
Hartkull	1	E-66	Handle Bare
Hartkwaal	9	E3	Handle Clamp Bolt and Nut (2)
Hartlappen	10	E-66	Throttle Valve
Hartlebig	11	B1	Throttle Valve Spring
Hartley	12	B4	Throttle Valve Seat
Hartlings	14	B1	Throttle Lever
Hartmangan	15	B1	Throttle Lever Pin (2)
Hartmossel	23	B6	Intermediate Lever
Hartobst	25	B1	Throttle Valve Cap
Hartobstes	....	....	Handle, Complete
Hartoor	2	E-66	Valve
Hartpijn	3	E-66	Valve Box Cap
Hartpijnen	4	E-66	Valve Box
Hartrindig	....	....	Valve Box, Complete Nos. 2, 3 and 4
Hartschild	5	E-66	Piston
Hartshorn	6	E-66	Cylinder No. 66
Hartsinn	6	E-99	Cylinder No. 99
Hartslag	20	B-66	Rivet Set Spring
Hartstich	22	B-66	Rivet Set Blank
Hartstueck	22A	B-66	Rivet Set Finished (to 1 inch)
Hartträber	22B	B-66	Rivet Set Finished (over 1 inch)
Hartvijl	27	B1	Wrench
Hartvlies	31	E-66	Strainer, Complete
Hartvormig	46	A1	Hose Nipple

The Care of "Imperial" Type "E" Hammers

It is doubtful if any piece of machinery pays greater profit on its cost than a Pneumatic Hammer in good working condition. It is also doubtful if any piece of high-speed machinery is so much abused by neglect as to cleaning and oiling.

It is essential to the good working and durability of all Pneumatic Hammers that they be kept *clean and well oiled*. This should not be delayed until the tool stops working on account of dirt, rust or gummed oil. Clean thoroughly with kerosene or benzine before oiling, when ready to put the tool in operation. Do this by immersing the entire tool in kerosene, or, better still, by suspending the tools completely immersed in kerosene when not in use.

All Hammers should be oiled through the hose nipple on the end of the handle before being put in service. Only good, light body oil should be used. Sewing machine oil is very good. Heavy oils should be avoided, as they gum up and cause the tool to work sluggishly, with consequent loss of power.

It will handsomely repay any user of Pneumatic Hammers to keep the inside of the tools as clean and well oiled as a sportsman does his gun.

The construction of "Imperial" hammers is such that none of the parts will break from service, and the tools will always work well and maintain their efficiency for an indefinite length of time if they are kept clean and oiled as above directed.

The Abuse of Short Pistons

Probably no labor-saving device (with the possible exception of the rock drill) is exposed to so much neglect, if not absolute abuse, as the pneumatic hammer under average working conditions. Without going into details as to the various elements which may cut down the efficiency of the hammer, particular attention is called at this time to one of the most flagrant abuses to which riveting hammers can be subjected. This is the substitution of short pistons.

The riveting hammer is carefully designed by its builders, with all parts properly proportioned and with the port layouts accurately determined, to meet the requirements of the particular class of work for which the tool is intended. Operators, however, have learned from experience that if a piston a fraction of an inch shorter than the standard piston is substituted, the hammer will deliver a hard, powerful blow and thus, temporarily at least, increase the amount of work which they can do in a given time. Disastrous results are sure to follow.

These short pistons, usually improperly hardened and of inferior material, have a tendency to break or crumble under the heavier blow. The broken parts cut or score the bore of the cylinder, and it is only a question of time until the cylinder is injured beyond repair or the handle is broken.

When cracked or cut cylinders, and broken handles and rivet sets are encountered, the cause is usually to be found in this substitution of short pistons. Even though the tool may have had the proper piston when delivered to the operator it has been found that workmen frequently carry with them the shorter pistons which are substituted for the right ones after taking the hammer out of the tool room.

After the work has been done the short piston is withdrawn and the right piston returned when the tool is turned in.

Attention is called to this point because experience has shown that a very large percentage of the failures in pneumatic riveting hammers can be traced to this cause.

Shipping Instructions

Attention is called to the fact that when it is necessary to return Imperial type "E" hammers to the factory for repairs or any other reasons they should be consigned to the Ingersoll-Rand Co., Athens, Pa.

GRIFFITH - STILLINGS PRESS
368 CONGRESS ST., BOSTON

"IMPERIAL" PISTON DRILLS

Ingersoll-Rand Company

11 BROADWAY, NEW YORK

Form No. 8005 February, 1911

Drilling on the Deck of a Ship

THE Ingersoll-Rand "Imperial" Pneumatic Piston Drill is a three-cylinder, balanced, reciprocating type embodying features of design which have won it an enviable position among high-class, high-duty pneumatic tools. In considering the merits of any labor-saving and cost-reducing machine, the conditions under which it is to do its work must be understood and their effect upon the performance of the tool must be taken into account. In a pneumatic drill, for instance, low power consumption alone is not a proper standard, or light weight, or a large capacity, or convenience, or wearing power.

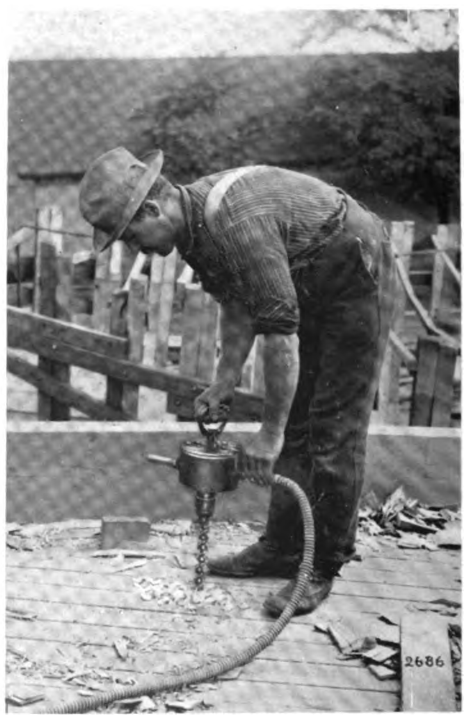
The best pneumatic drill is the one which best combines all of these desirable elements, in a sturdy, "all-around" tool which does good work on a fair power consumption and keeps up its good

work indefinitely because of its high-class design, materials and construction.

Such a tool is the "Imperial" Piston Drill, designed not for record-breaking performance, but for steady, month-after-month service with power and up-keep costs moderate and reasonably in proportion to the work accomplished. It is adapted, in its various sizes, for all the ordinary work of the pneumatic drill — drilling, reaming, tapping and flue rolling. The features of convenience and ready control have been especially well provided for.

The "Imperial" motor is of the three-cylinder reciprocating type, the cylinders being equally spaced radially around a common center. The cylinders with their pistons revolve around a strong main bearing which serves as a valve. This one central valve controls the admission and exhaust for all three cylinders. The valve seat is a tapered bronze bushing in the center between the cylinders, and any wear may be taken up by driving this bushing further in. The design is such that the live air pressure on each active piston automatically presses the valve against its seat throughout the stroke. This means that there is no chance for leakage of live air due to wear of valve or seat; for wear, as it may occur, is automatically taken up by the pressure on the piston.

Especial care has been taken to make the "Imperial" a serviceable, permanently economical drill. To this end, all bearings are made large and the most important ones are bushed with removable anti-friction bushings. Light weight is provided without sacrifice of strength by making most of the parts of drop-forged steel of high quality. The revolving parts are per-



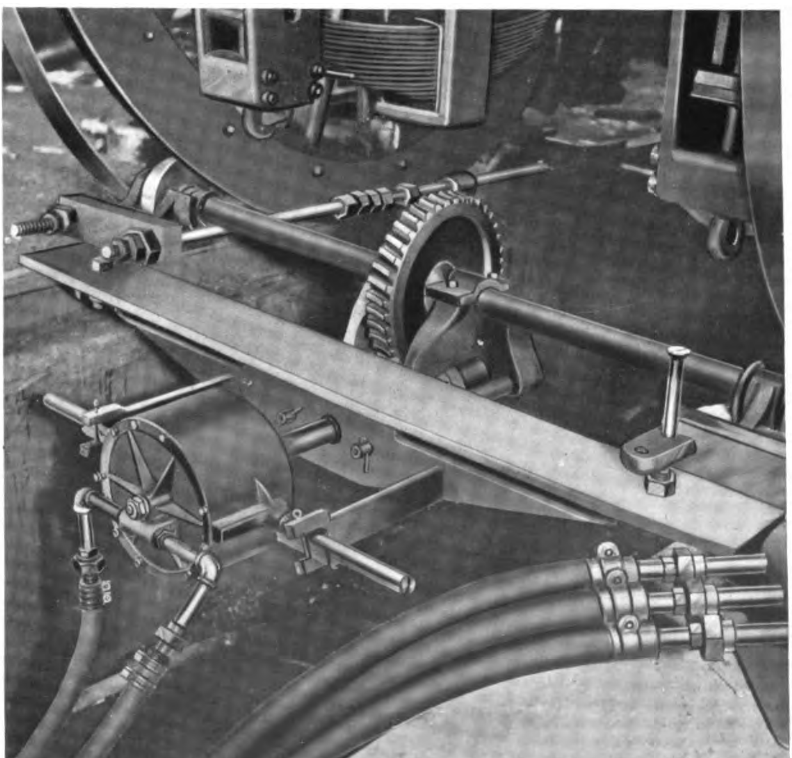
"Imperial" Wood Boring Machine at Work

fectly balanced and, rotating about a common center, there is no vibration at any speed.

All parts are amply strong for the duty upon them, and are well secured in position to guard against derangement and break-down. Probably in no tool is the need for proper lubrication greater than in a high-speed pneumatic drill. In the "Imperial" every precaution has been taken to provide for the free and ample oiling of all bearings.

There is no drill on the market offering a higher grade of design, materials and workmanship than the "Imperial." With reasonable care in handling it and in proper cleaning and oiling, the "Imperial" will show a performance which will satisfy the most exacting demands.

The table on page 4 gives the dimensions, capacity, and other information on the standard "Imperial" line. The pages following illustrate the various sizes in their relative proportions.



"Imperial" No. 4 Drill Modified for Locomotive Valve setting Twenty-six of these Machines are in use at the West Albany Shops of the New York Central R.R. Co.

"IMPERIAL" PNEUMATIC PISTON DRILLS

STYLE	SIZE	Weight, pounds	Length, inches	Length of feed, inches	Diameter from side to center of spindle, inches	Morse Taper Socket, inches	Square Tap Socket, inches	Size Twist Drill will drive, inches	Size of wood bit will drive, inches	Reaming, inches	Tapping, inches	Flue Rolling, inches	R. P. M. at 80 pounds	Cubic feet of free air at 80 pounds	Hose Connection, inches
NOT REVERSIBLE	2	48	20⅝	4	4⅜	3	$\frac{9}{16}$	1¼	....	1	1	....	290	25	¾
" "	3	52	22¾	4	4⅜	4	$\frac{9}{16}$	2¼	....	2	2	....	290	35	¾
REVERSIBLE	1	27	19⅝	3	3⅝	3	....	1	....	¾	¾	....	220	20	½
"	4	70	23¼	4	5¼	4	$\frac{9}{16}$	3	....	2½	2½	4	170	45	¾
"	11	27	14⅛	....	3⅝	....	....	....	2½	....	....	....	350	20	½
"	12	48	20⅝	4	4⅜	3	$\frac{9}{16}$	1¼	4	1	1	2½	275	25	¾
"	13	52	22¾	4	4⅜	4	$\frac{9}{16}$	2½	....	2	2	3	235	35	¾
"	21	27	19⅝	3	3⅝	2	....	⅞	....	½	½	....	350	20	½
VALVE SETTING MACHINE	4	70	....	....	5¼	For use on the Larger Sizes of Locomotives							170	45	¾

"Imperial" Drill on Ship Repair Work

NON-REVERSIBLE DRILLS

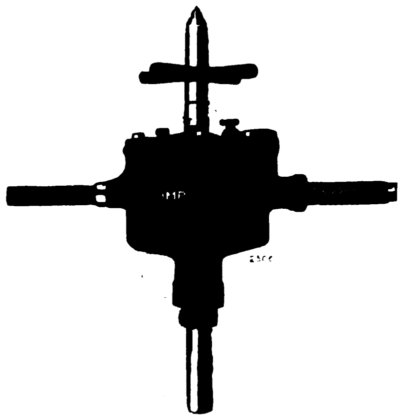
No. 2 "IMPERIAL" PISTON DRILL

For Drilling, Reaming and Tapping. Fitted with No. 3 Morse Taper Socket and $\frac{9}{16}$-inch Square Tap Socket

No. 3 "IMPERIAL" PISTON DRILL

For Heavy Metal Drilling, Reaming and Tapping. Fitted with No. 4 Morse Taper Socket and $\frac{9}{16}$-inch Square Tap Socket

REVERSIBLE DRILLS



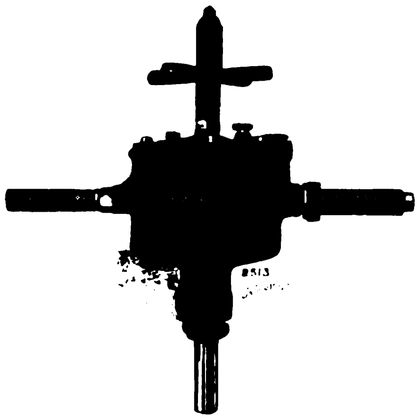
No. 1 "IMPERIAL" PISTON DRILL

For Drilling, Reaming and Tapping. Fitted with No. 3 Morse Taper Socket

No. 11 "IMPERIAL" PISTON DRILL

For Wood boring. Fitted with Spade Handle and Chuck for 2½-inch Wood Boring Auger

REVERSIBLE DRILLS



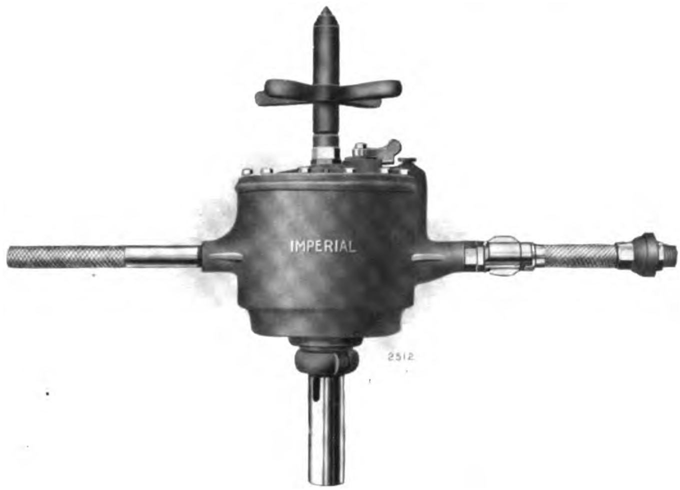
No. 21 "IMPERIAL" PISTON DRILL

For Drilling, Reaming and Tapping. Fitted with No. 2 Morse Taper Socket

No. 12 "IMPERIAL" PISTON DRILL

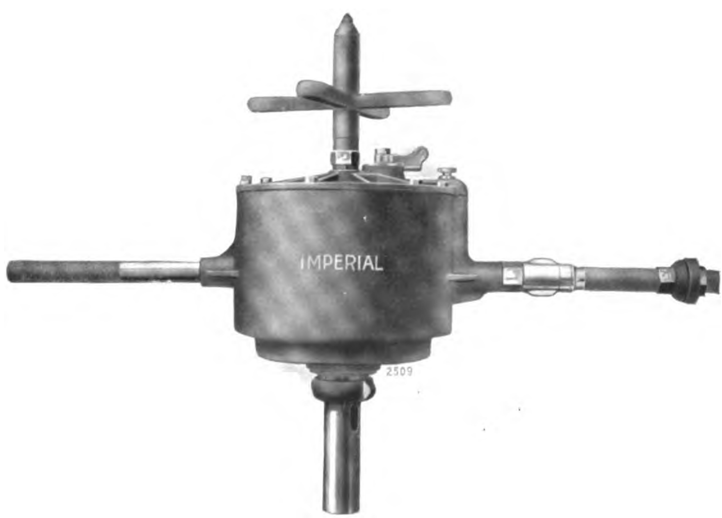
For Drilling, Reaming, Tapping and Flue Rolling. Fitted with No. 3 Morse Taper Socket and $\frac{9}{16}$-inch Square Tap Socket

REVERSIBLE DRILLS



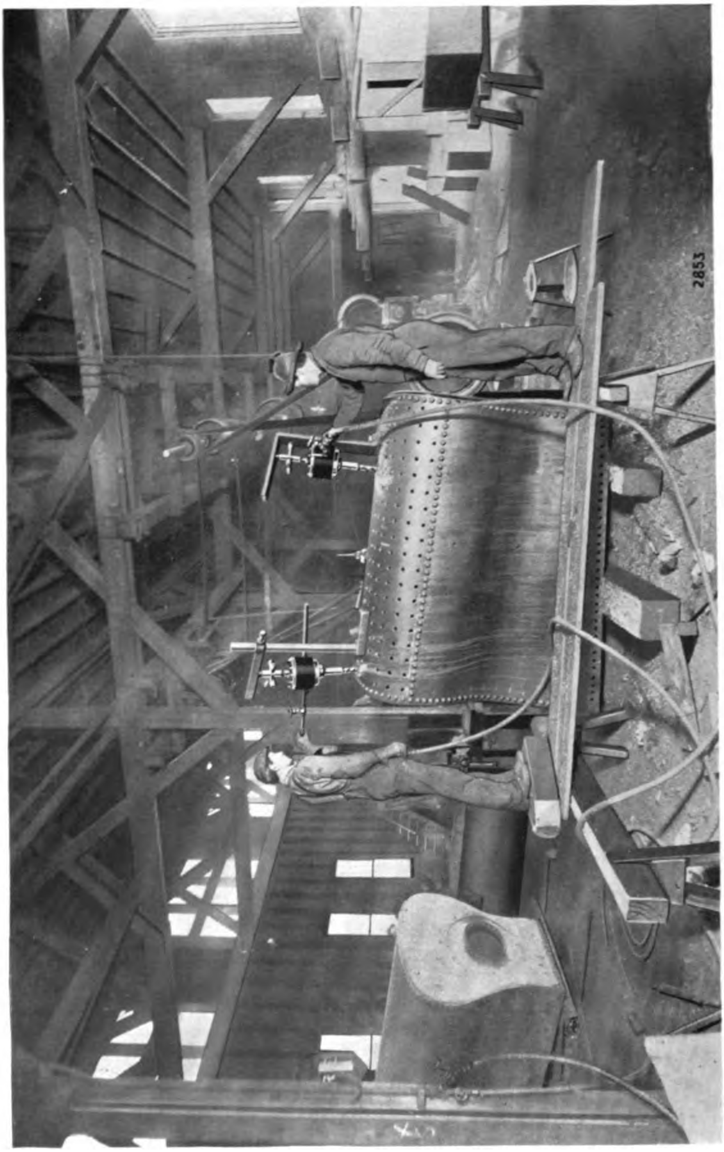
No. 13 "IMPERIAL" PISTON DRILL

For Heavy Drilling, Reaming, Tapping and Flue Rolling. Fitted with No. 4 Morse Taper Socket and $\frac{9}{16}$-inch Square Tap Socket

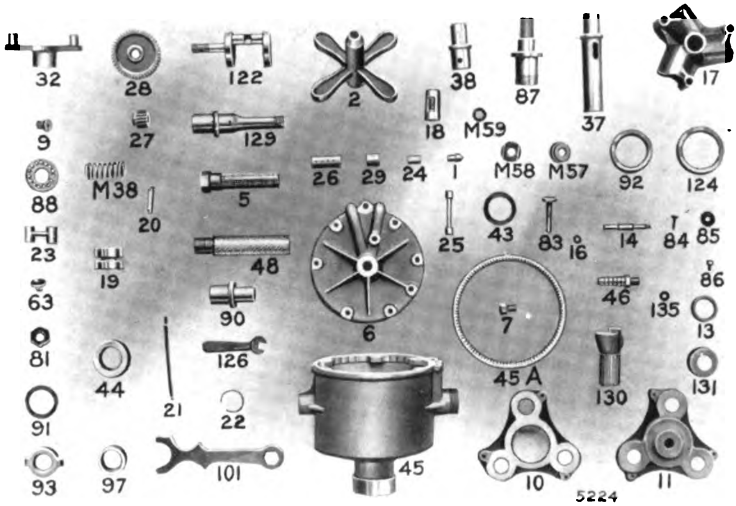


No. 4 "IMPERIAL" PISTON DRILL

For Extra Heavy Drilling, Reaming, Tapping and Flue Rolling. Fitted with No. 4 Morse Taper Socket and $\frac{9}{16}$-inch Square Tap Socket

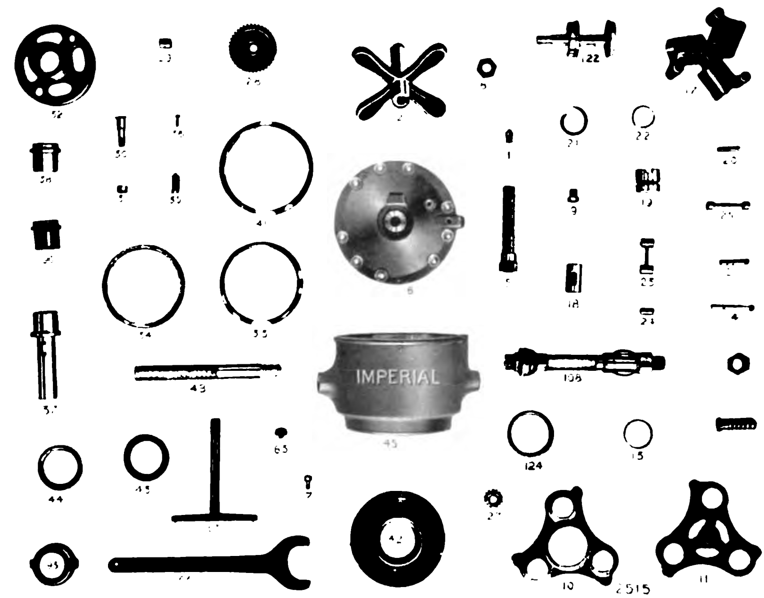


"Imperial" Piston Drills at work on Locomotive Fire Box, Seaboard Air Line Shops.
This Company uses more than Twenty-five "Imperial" Drills



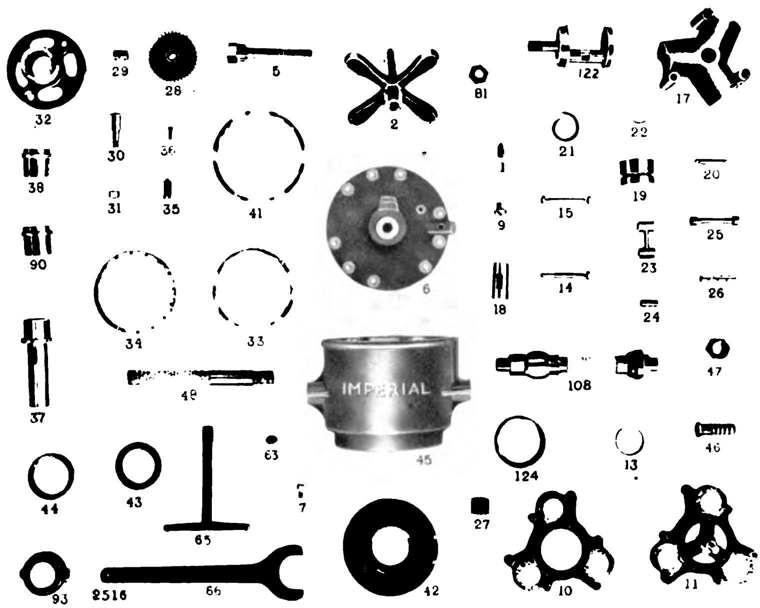
Duplicate Part List of No. 1 "Imperial" Drill

1 Feed Nut Center
2 Feed Nut
5 Feed Screw
6 Top Cover
7 Top Cover Screw
9 Crank Disc Screw
10 Guide Frame
11 Drive Frame
13 Frame Bushing
14 Frame Bolt
16 Frame Bolt Nut
17 Cylinder
18 Cylinder Bushing
19 Piston
20 Piston Pin
21 Piston Packing
22 Piston Spring
23 Connecting Rod
24 Rod Bushing
25 Roller
26 Roller Bushing
27 Pinion
28 Intermediate Gear
29 Gear Bushing
32 Gearhead
37 Morse Taper Socket
38 Reamer Chuck
M38 Throttle Handle Spring
43 Spindle Packing
44 Packing Nut
45 Case
45A Internal Gear Rack
46 Hose Nipple
48 Plain Handle
M57 Throttle Handle Base
M58 Throttle Handle Cap
M59 Throttle Handle Strainer
63 Oil Hole Plug
81 Crank Nut
83 Pinion Screw
84 Gear Stud Screw
85 Gear Stud Washer
86 Gearhead Screw
87 Spindle
88 Spindle Bearing
90 Square Taper Socket
91 Spindle Packing Seat
92 Packing Nut Lock
93 Spindle Nut
97 Case Bushing
101 Combination Spanner
122 Crank
124 Frame Ball Cup
126 Cap Bolt Wrench
129 Throttle Handle
130 Throttle Handle Valve
131 Throttle Handle Nut
135 Roller Stem Washer.
Balls, $\frac{3}{16}$ inch diameter



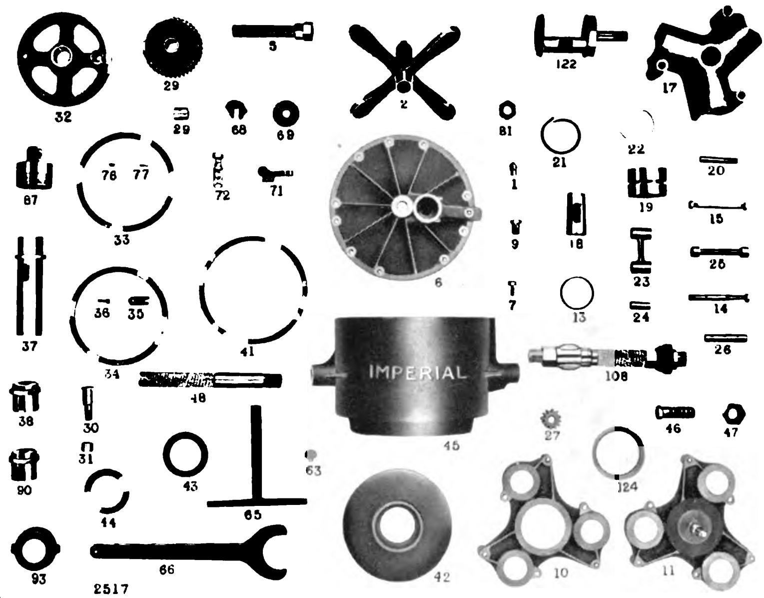
Duplicate Parts of No. 2 "Imperial" Drill

1 Feed Nut Center
2 Feed Nut
5 Feed Screw
6 Top Cover
7 Top Cover Cap Screw
9 Crank Disc Screw
10 Guide Side Frame
10A Guide Side Frame complete with Nos. 124 and 13
11 Drive Side Frame
11B Drive Side Frame complete with Nos. 124, 13 and 27
13 Frame Bushing
14 Frame Bolt
16 Frame Bolt Nuts
17 Cylinder
18 Cylinder Bushing
19 Piston
20 Piston Pin
21 Piston Packing
22 Piston Packing Spring
23 Connecting Rod
24 Connecting Rod Bushing
25 Roller
26 Roller Bushing
27 Pinion
28 Intermediate Gear
29 Gear Bushing
30 Gear Stud
31 Gear Stud Nut
32 Gearhead
33 Gearhead Cone
34 Gearhead Cone Adjusting Ring
35 Adjusting Ring Lock
36 Ring Lock Screw
37 Morse Taper Socket
38 Reamer Chuck
41 Case Ball Race
42 Bottom Cover
43 Spindle Packing
44 Packing Nut
45 Case
46 Hose Nipple
48 Plain Handle
63 Oil Hole Plug
65 Gearhead Spanner
66 Bottom Cover Spanner
81 Crank Nut
90 Square Taper Socket
93 Spindle Nut
108 Throttle Handle complete
122 Crank Complete
124 Frame Ball Cup
$\frac{3}{8}$ inch Balls



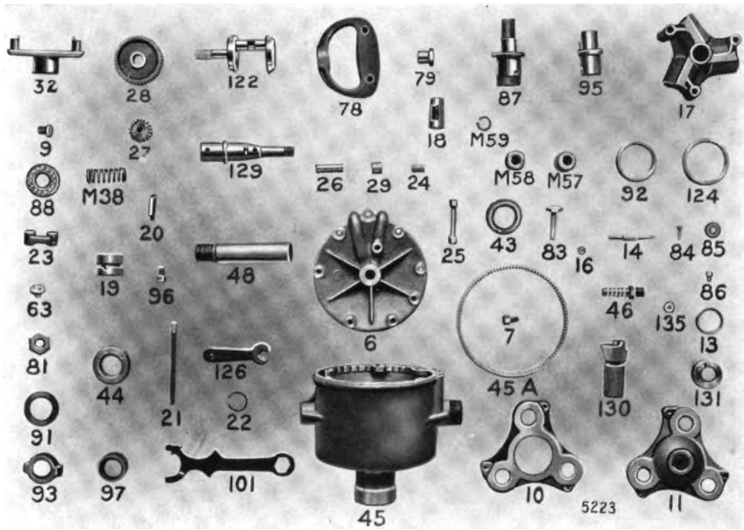
Duplicate Parts of No. 3 "Imperial" Drill

1 Feed Nut Center
2 Feed Nut
5 Feed Screw
6 Top Cover
7 Top Cover Cap Screws
9 Crank Disc Screw
10 Guide Side Frame
10A Guide Side Frame complete with Nos. 124 and 13
11 Drive Side Frame
11B Drive Side Frame complete with Nos. 124, 13 and 27
13 Frame Bushing
14 Frame Bolt
15 Frame Separator
16 Frame Bolt and Separator Nuts
17 Cylinder
18 Cylinder Bushing
19 Piston
20 Piston Pin
21 Piston Packing
22 Piston Packing Spring
23 Connecting Rod
24 Connecting Rod Bushing
25 Roller
26 Roller Bushing
27 Pinion
28 Intermediate Gear
29 Gear Bushing
30 Gear Stud
31 Gear Stud Nut
32 Gearhead
33 Gearhead Cone
34 Gearhead Cone Adjusting Ring
35 Adjusting Ring Lock
36 Ring Lock Screw
37 Morse Taper Socket
38 Reamer Chuck
41 Case Ball Race
42 Bottom Cover
43 Spindle Packing
44 Packing Nut
45 Case
46 Hose Nipple
48 Plain Handle
63 Oil Hole Plug
65 Gearhead Spanner
66 Bottom Cover Spanner
81 Crank Nut
90 Square Taper Socket
93 Spindle Nut
108 Throttle Handle complete
122 Crank Complete
124 Frame Ball Cup
127 Pinion Key (not shown)
128 Pinion Nut (not shown)
$\frac{3}{8}$ inch Balls



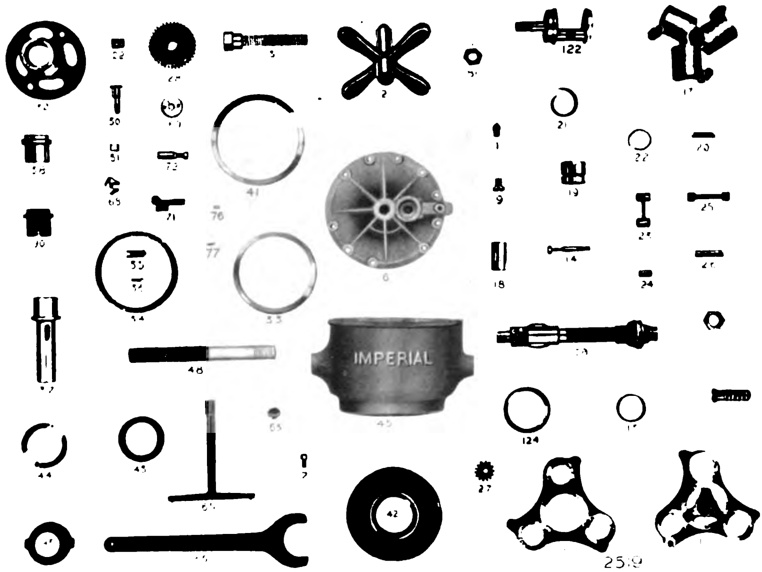
Duplicate Parts of No. 4 "Imperial" Drill

1 Feed Nut Center
2 Feed Nut
5 Feed Screw
6 Top Cover
7 Top Cover Cap Screw
9 Crank Disc Screw
10 Guide Side Frame
10A Guide Side Frame complete with Nos. 124 and 13
11 Drive Side Frame
11B Drive Side Frame complete with Nos. 124, 13 and 27
13 Frame Bushing
14 Frame Bolt
15 Frame Separator
16 Frame Bolt and Separator Nuts
17 Cylinder
18 Cylinder Bushing
19 Piston
20 Piston Pin
21 Piston Packing
22 Piston Packing Spring
23 Connecting Rod
24 Connecting Rod Bushing
25 Roller
26 Roller Bushing
27 Pinion
28 Intermediate Gear
29 Gear Bushing
30 Gear Stud
31 Gear Stud Nut
32 Gearhead
33 Gearhead Cone
34 Gearhead Cone Adjusting Ring
35 Adjusting Ring Lock
36 Ring Lock Screw
37 Morse Taper Socket
38 Reamer Chuck
41 Case Ball Race
42 Bottom Cover
43 Spindle Packing
44 Packing Nut
45 Case
48 Plain Handle
63 Oil Hole Plug
65 Gearhead Spanner
66 Bottom Cover Spanner
68 Reverse Valve
69 Reverse Valve Cover
71 Reverse Valve Handle
72 Reverse Valve Stem
73 Reverse Valve Stem Nut
76 Valve Handle Latch Pin
77 Latch Pin Spring
81 Crank Nut
87 Spindle
90 Square Taper Socket
93 Spindle Nut
108 Throttle complete
122 Crank complete
124 Frame Ball Cup
$\frac{3}{8}$ inch Balls



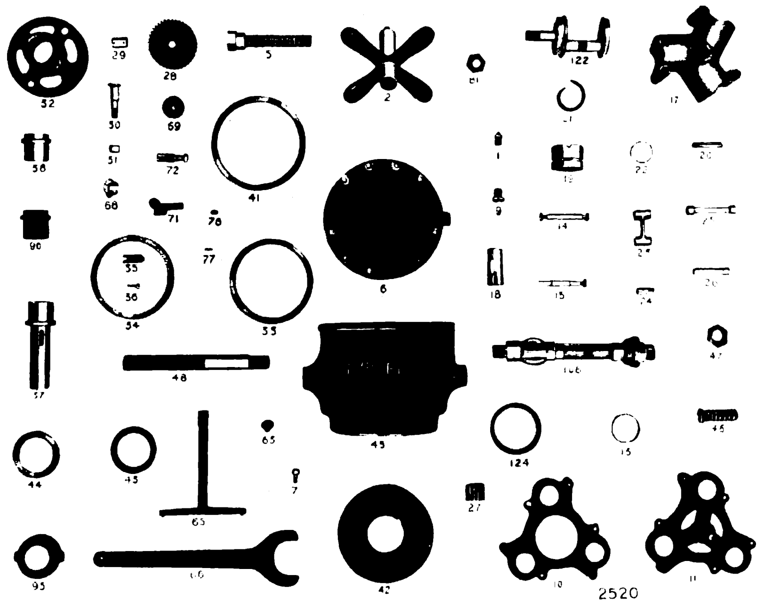
Duplicate Parts of No. 11 "Imperial" Drill

6	Top Cover
7	Top Cover Screw
9	Crank Disc Screw
10	Guide Frame
11	Drive Frame
13	Frame Bushing
14	Frame Bolt
16	Frame Bolt Nut
17	Cylinder
18	Cylinder Bushing
19	Piston
20	Piston Pin
21	Piston Packing
22	Piston Spring
23	Connecting Rod
24	Rod Bushing
25	Roller
26	Roller Bushing
27	Pinion
28	Intermediate Gear
29	Gear Bushing
32	Gearhead
M38	Throttle Handle Spring
43	Spindle Packing
44	Packing Nut
45	Case
45A	Internal Gear Rack
46	Hose Nipple
48	Plain Handle
M57	Throttle Handle Base
M58	Throttle Handle Cap
M59	Throttle Handle Strainer
63	Oil Hole Plug
78	Grip Handle
79	Grip Handle Stud
81	Crank Nut
83	Pinion Screw
84	Gear Stud Screw
85	Gear Stud Washer
86	Gearhead Screw
87	Spindle
88	Spindle Bearing
91	Spindle Packing Seat
92	Packing Nut Lock
93	Spindle Nut
95	Bit Chuck
96	Bit Chuck Set Screw
97	Case Bushing
101	Combination Spanner
122	Crank
124	Frame Ball Cup
126	Cap Bolt Wrench
129	Throttle Handle
130	Throttle Handle Valve
131	Throttle Handle Nut
135	Roller Steam Washer, Balls, $\frac{5}{16}$ inch diameter



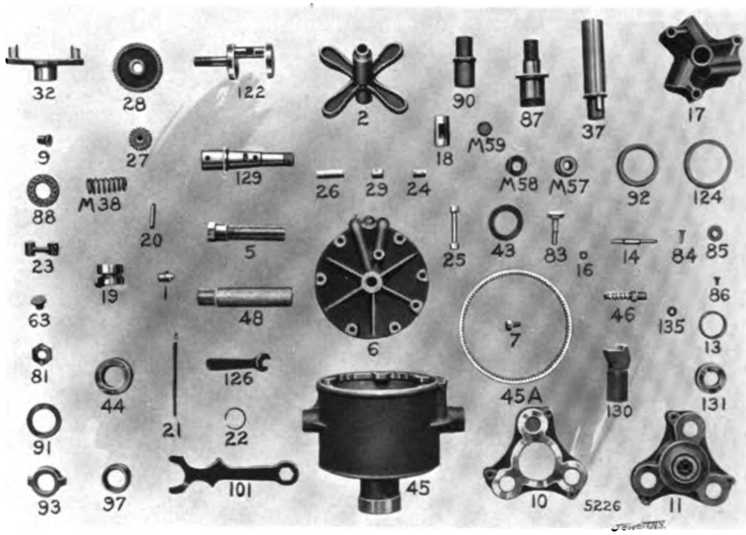
Duplicate Parts of No. 12 "Imperial" Drill

1 Feed Nut Center
2 Feed Nut
5 Feed Screw
6 Top Cover
7 Top Cover Cap Screws
9 Crank Disc Screw
10 Guide Side Frame
10A Guide Side Frame complete with Nos. 124 and 13
11 Drive Side Frame
11B Drive Side Frame complete with Nos. 124, 13 and 27
13 Frame Bushing
14 Frame Bolt
16 Frame Bolt Nuts
17 Cylinder
18 Cylinder Bushing
19 Piston
20 Piston Pin
21 Piston Packing
22 Piston Packing Spring
23 Connecting Rod
24 Connecting Rod Bushing
25 Roller
26 Roller Bushing
27 Pinion
28 Intermediate Gear
29 Gear Bushing
30 Gear Stud
31 Gear Stud Nut
32 Gearhead
33 Gearhead Cone
34 Gearhead Cone Adjusting Ring
35 Adjusting Ring Lock
36 Ring Lock Screw
37 Morse Taper Socket
38 Reamer Chuck
41 Case Ball Race
42 Bottom Cover
43 Spindle Packing
44 Packing Nut
45 Case
48 Plain Handle
63 Oil Hole Plug
65 Gearhead Spanner
66 Bottom Cover Spanner
68 Reverse Valve
69 Reverse Valve Cover
71 Reverse Valve Handle
72 Reverse Valve Stem
73 Reverse Valve Stem Nut
76 Valve Handle Latch Pin
77 Latch Pin Spring
81 Crank Nut
90 Square Taper Socket
93 Spindle Nut
108 Throttle Handle complete
122 Crank complete
124 Frame Ball Cup
$\frac{3}{8}$ inch Balls



Duplicate Parts of No. 13 "Imperial" Drill

1 Feed Nut Center
2 Feed Nut
5 Feed Screw
6 Top Cover
7 Top Cover Cap Screws
9 Crank Disc Screw
10 Guide Side Frame
10A Guide Side Frame complete with Nos. 124 and 13
11 Drive Side Frame
11B Drive Side Frame complete with Nos. 124, 13 and 27
13 Frame Bushing
14 Frame Bolt
15 Frame Separator
16 Frame Bolt and Separator Nuts
17 Cylinder
18 Cylinder Bushing
19 Piston
20 Piston Pin
21 Piston Packing
22 Piston Packing Spring
23 Connecting Rod
24 Connecting Rod Bushing
25 Roller
26 Roller Bushing
27 Pinion
28 Intermediate Gear
29 Gear Bushing
30 Gear Stud
31 Gear Stud Nut
32 Gearhead
33 Gearhead Cone
34 Gearhead Cone Adjusting Ring
35 Adjusting Ring Lock
36 Ring Lock Screw
37 Morse Taper Socket
38 Reamer Chuck
41 Case Ball Race
42 Bottom Cover
43 Spindle Packing
44 Packing Nut
45 Case
48 Plain Handle
63 Oil Hole Plug
65 Gearhead Spanner
66 Bottom Cover Spanner
68 Reverse Valve
69 Reverse Valve Cover
71 Reverse Valve Handle
72 Reverse Valve Stem
73 Reverse Valve Stem Nut
76 Valve Handle Latch Pin
77 Latch Pin Spring
81 Crank Nut
90 Square Taper Socket
93 Spindle Nut
108 Throttle Handle complete
122 Crank complete
124 Frame Ball Cup
127 Pinion Key (not shown)
128 Pinion Nut (not shown)
3/8 inch Balls



Duplicate Parts of No. 21 "Imperial" Drill

1 Feed Nut Center
2 Feed Nut
5 Feed Screw
6 Top Cover
7 Top Cover Screw
9 Crank Disc Screw
10 Guide Frame
11 Drive Frame
13 Frame Bushing
14 Frame Bolt
16 Frame Bolt Nut
17 Cylinder
18 Cylinder Bushing
19 Piston
20 Piston Pin
21 Piston Packing
22 Piston Spring
23 Connecting Rod
24 Rod Bushing
25 Roller
26 Roller Bushing
27 Pinion
28 Intermediate Gear
29 Gear Bushing
32 Gearhead
37 Morse Taper Socket
M38 Throttle Handle Spring
43 Spindle Packing
44 Packing Nut
45 Case
45A Internal Gear Rack
46 Hose Nipple
48 Plain Handle
M57 Throttle Handle Basc
M58 Throttle Handle Cap
M59 Throttle Handle Strainer
63 Oil Hole Plug
81 Crank Nut
83 Pinion Screw
84 Gear Stud Screw
85 Gear Stud Washer
86 Gear Head Screw
87 Spindle
88 Spindle Bearing
90 Square Taper Socket
91 Spindle Packing Seat
92 Packing Nut Lock
93 Spindle Nut
97 Case Bushing
101 Combination Spanner
122 Crank
124 Frame Ball Cup
126 Cap Bolt Wrench
*129 Throttle Handle
*130 Throttle Handle Valve
131 Throttle Handle Nut
135 Roller Stem Washer,
Balls, $\frac{5}{16}$ inch diameter

* Photo apparently shows these reversed.

CARE OF THE DRILLS

Careful and systematic attention to the cleaning and lubricating of these tools will show large returns for such care. The motors of pneumatic drilling machines run at a very high rate of speed, and proper lubrication is absolutely essential to keep them in good working order. These machines are necessarily of a very high grade of workmanship to insure efficiency, and the working parts must be kept by lubrication from cutting or undue wear, or the power of the machine will be seriously lessened.

Kerosene is best to use for cleaning the machine, and if the machine has not been used for several days a liberal supply of kerosene should be poured in the end of the handle, as well as in the oil cocks or plug openings and the machine run for a few minutes and then oiled with a light-body lubricating oil. Sewing machine oil is good to use, as well as any of the special pneumatic tool oils on the market. We especially recommend our pneumatic tool oil "Sprayoleum." Heavy oil should never be used, as the compressed air for operating the tool lowers the temperature and causes heavy oil to become gummy, which interferes with the speed and power of the motor.

Drills when new and first started should be oiled at least once each hour for the first two or three days, and every two hours thereafter when in operation.

The recommended air pressure for these drills is from 80 to 100 pounds. This means pressure at the tool, not gauge pressure at the receiver.

When taking a lead of as much as fifty feet from the pipe line it is best to use a ¾-inch hose, reducing it to ½-inch about ten feet from the tool. The object of using the ¾-inch hose is to get the air up to the tool at full pressure, and the ten-foot length of ½-inch hose is for flexibility, making it easier for the operator to handle the tool. Where the leads are not more than twenty-five feet, ½-inch hose is satisfactory.

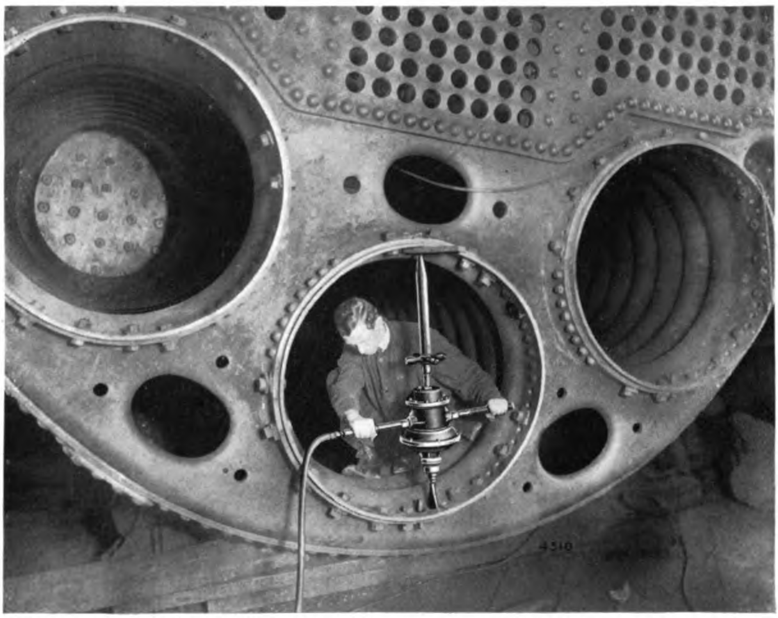
"Imperial" Wood Boring Drill

Griffith-Stillings Press
Boston, Mass.

"CROWN" ROTARY PNEUMATIC DRILLS

INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 8004 September, 1910



"Crown" Drill on a Marine Boiler Job

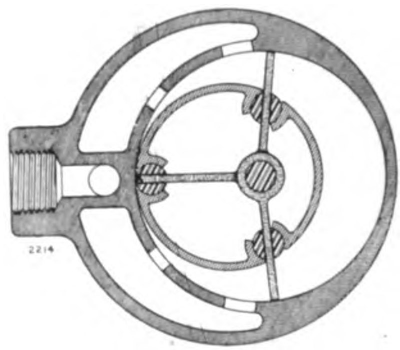
THE "Crown" Rotary Pneumatic Drill differs from the "Imperial" Drill, also built by the Ingersoll-Rand Company, in the fact that it uses a rotary motor, as distinguished from the three-cylinder piston motor of the "Imperial." The distinctive feature of the "Crown" Drill is its simplicity, which comes from the use of the rotary motor having remarkably few parts.

In details of construction, "Crown" Drills measure up to the most exacting standards. Steels used are of selected quality, and are hardened or toughened as requirements demand. Anti-friction metals are judiciously applied in the bearings. Cast metal parts are of a tough, uniform texture. Weight has been reduced to the limit without sacrifice of the strength and rigidity

so essential in a high-class tool. Parts are strictly interchangeable and are "guaranteed to fit." Every improvement looking to convenience and ease of operation has been used. The finished product is a drill light, convenient, powerful, economical and reliable, equal to the most severe demands with continued satisfactory operation.

The "Crown" Motor

The diagram herewith shows a section through the motor of the "Crown" Drill. The cylinder bore is eccentric to the drill spindle; the piston is concentric with the spindle, but eccentric to the cylinder. Three radial blades pivoted on an eccentric pin pass through slotted rocker pins in the piston wall. Air pressure on these blades forces them— and the piston with them— around in the cylinder, causing the rotation of the shaft.



Sectional Diagram of "Crown" Drill Motor

All rotating parts turn on their own centers, without reaction, side thrust, or unbalanced pressure on bearings or cylinder wall. Wear comes first upon the eccentric pin bearing, which is exceptionally large. The blades normally just clear the cylinder walls; if their bearing wears, centrifugal force throws them out and they automatically grind to a proper fit in the cylinder. The travel of the blades in the rocker pins is so slight that wear here is negligible. No rotary motor ever designed is so well guarded against depreciation and loss of efficiency due to wear. It is to be noted that there is almost no clearance space—another important factor in economy.

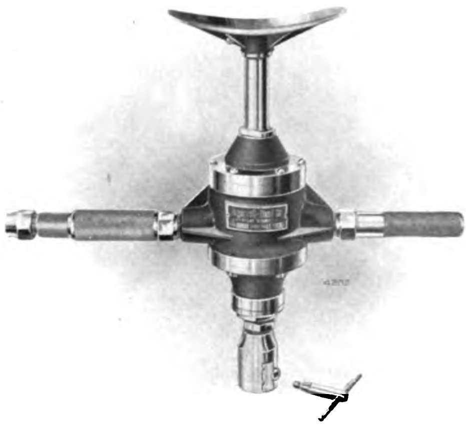
All principal bearings have renewable bushings. The space between upper cylinder head and top casing is filled with oil which slowly feeds to all parts of the drill. The hollow piston is also filled with a grease which lubricates the interior bearings. Air is admitted through one handle provided with a quick-acting throttle. Reversible types have in addition a reversing lever on the upper casing. Speed is regulated by varying the air supply with the throttle.

On the opposite page are tabulated specifications of the complete line of "Crown" Drills, giving the important dimensions and the work for which each size is adapted. On pages 4 to 7 inclusive the eight standard "Crown" Drills are illustrated in their relative proportion.

Specifications of "Crown" Pneumatic Drills

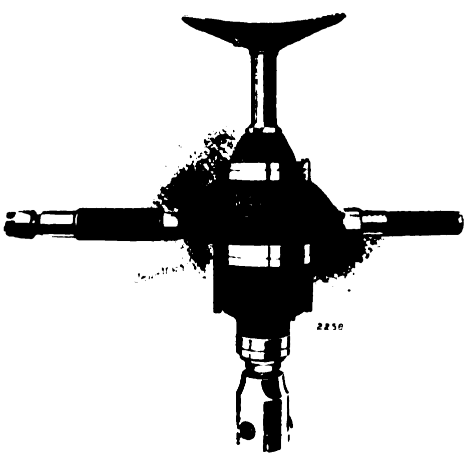
Style.	Symbol.	Weight, lbs.	Length of Feed, Inches.	Shortest Dist. Center to Edge, Inches.	Morse Taper Socket.	Sq. Tap Socket.	Maximum Diameter of Tool For Which Adapted, Inches.					R. P. M. Spindle at 80 lbs.	Cu. Ft. Free Air per Min. at 80 lbs.	Hose Con., Inches.
							Drill.	Reamer.	Tap.	Flue Roller.	Wood Bit.			
Non-Reversible	1R	14	..	2	1	..	3/8	..	..	..	1	700	40	1/2
" "	12R	17	2 3/4	2	1	..	19/32	..	..	.	.	425	40	1/2
" "	13R	28	2 3/4	3 1/2	3	5/8	1 1/4	13/16	1	..	..	300	50	1/2
" "	16R	55	3 3/4	4 5/8	4	1	2	1 1/4	1 1/2	..	..	200	70	1/2
Reversible	14R	30	2 3/4	3 1/2	3	5/8	1 1/4	13/16	1	2	..	300	50	1/2
"	15R	25	..	3 1/2	..	..	..	..	..	..	3	215	50	1/2
"	5R	57	3 3/4	4 5/8	4	1	2	1 1/4	1 1/2	3	..	200	70	1/2
"	6R	62	3 3/4	4 5/8	4	1	3	2 1/2	2 1/2	4	..	75	70	1/2

Non-Reversible Drills



No. 1R "Crown" Pneumatic Drill

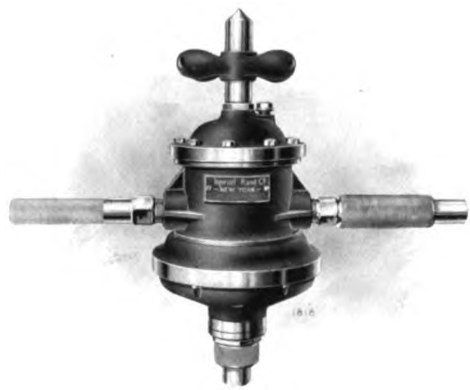
For Wood Boring and Metal Drilling. For Wood Boring, Fitted with Spade Handle and ½ x 2 inch Auger Chuck. For Metal Drilling, Fitted with Feed Screw and No. 1 Morse Taper Socket, or with Breast Plate and Two-Jaw Chuck.



No. 12R "Crown" Pneumatic Drill

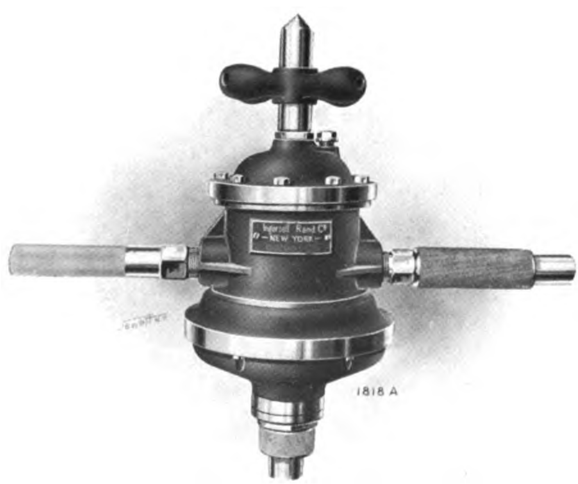
For Metal Drilling. Standard Machine Fitted with Feed Screw and No. 1 Morse Taper Socket. Breast Plate and Two-Jaw Chuck Substituted on Order.

Non-Reversible Drills



No. 13R "Crown" Pneumatic Drill

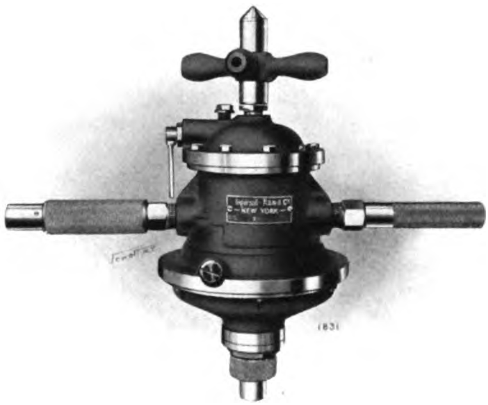
For Drilling, Reaming and Tapping. Fitted with No. 3 Morse Taper Socket and $\frac{5}{8}$-inch Square Tap Socket.



No. 16R "Crown" Pneumatic Drill

For Drilling, Reaming and Tapping. Fitted with No. 4 Morse Taper Socket and 1-inch Square Tap Socket.

Reversible Drills



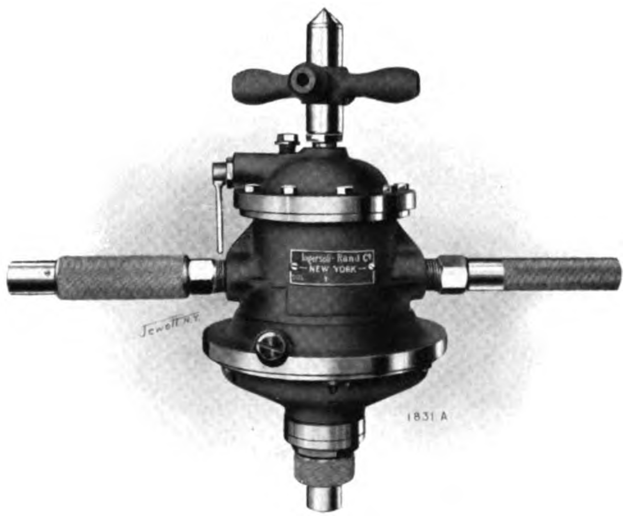
No. 14R "Crown" Pneumatic Drill

For Drilling, Reaming, Tapping and Flue Rolling. Fitted with No. 3 Morse Taper Socket and ⅝-inch Square Tap Socket.

No. 15R "Crown" Pneumatic Drill

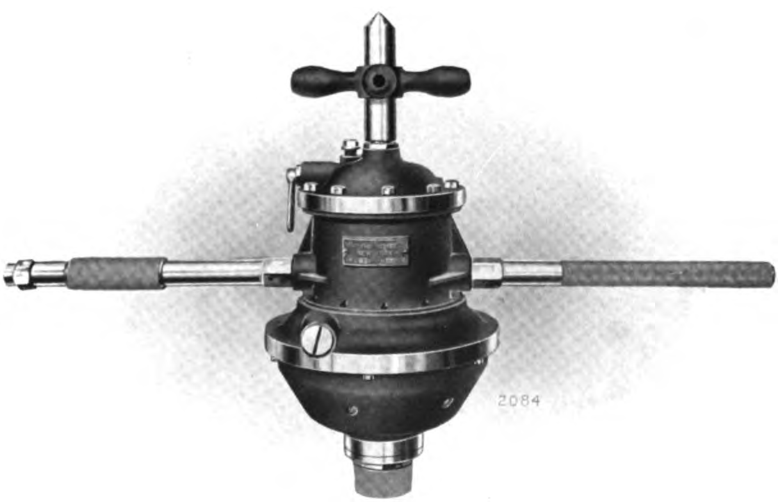
For Wood Boring Only. Fitted with Spade Handle and ⅞ x 2-inch Auger Chuck.

Reversible Drills



No. 5R "Crown" Pneumatic Drill

For Drilling, Reaming, Tapping and Flue Rolling. Fitted with No. 4 Morse Taper Socket and 1-inch Square Tap Socket.



No. 6R "Crown" Pneumatic Drill

For Drilling, Reaming, Tapping and Flue Rolling. Fitted with No. 4 Morse Taper Socket and 1-inch Square Tap Socket.

Care of "Crown" Drills

CAREFUL and systematic attention to the cleaning and proper lubricating of "Crown" Drills will show large returns on the time and effort expended.

The motors of these machines run at a very high speed, and proper lubrication is absolutely essential to keep them in good working order. The workmanship in these drills is of a very high grade in order to insure high efficiency, and the working parts must be protected by adequate lubrication from cutting or undue wear. Otherwise the power of the machine will be seriously reduced and wear made more rapid.

Kerosene is the best medium for cleaning the machine; and if the drill has not been used for several days a liberal supply of kerosene should be poured in the end of the handle and the machine run for a few minutes. This will cut or loosen any accumulations of thick oil, and the drill should then be oiled with some heavy-body lubricating oil.

Steam cylinder oil is the proper lubricant to use for "Crown" drills. The Ingersoll-Rand Company particularly recommends its special brand known as "600 W" Cylinder Oil, a sample of which is furnished with each machine.

Light oils should never be used in these machines, as they are carried through with the air and have no lasting qualities for motors of this type.

Filling the inside of the piston with a heavy grease will prevent the motor from heating up when used in continuous service.

Drills when new and first started should be oiled at least once an hour for the first two or three days and every two hours thereafter when in operation.

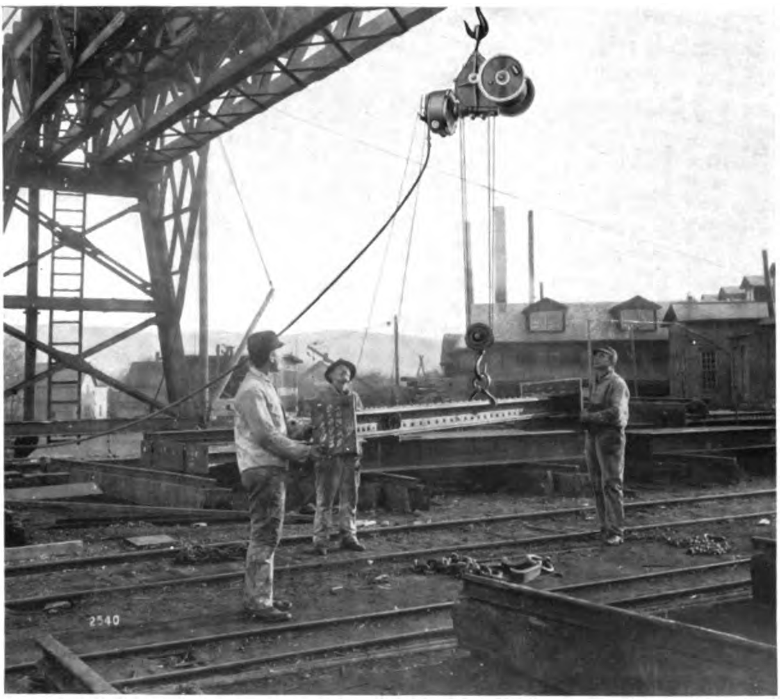
Press of J. J. Little & Ives Co.
New York

"IMPERIAL" MOTOR HOISTS & STATIONARY MOTORS

Ingersoll-Rand Company

11 BROADWAY, NEW YORK

Form No. 8006 February, 1911



"Imperial" Hoist Handling Structural Steel

THE quick and economical handling of work and materials is of vital importance in the industrial field today. Lifting and hoisting done by machine instead of by hand saves labor and time. Floor space otherwise cumbered is kept clear for new work. The time required for passing a job from one stage of production to another is reduced. Efficient, handy and reliable hoisting devices are being more and more recognized as actually effective in reducing production costs, increasing output and adding to the profits.

The "Imperial" Motor Hoist is a machine which has demon-

strated its superiority, its money-making capacity, in such a diversity of fields that it may be said to be the "standard" hoist for this class of light hoisting. With hundreds of these machines in use, a failure is yet to be recorded against them, and "repeat orders" evidence the entire satisfaction of the trade.

The "Imperial" Hoist is entirely distinct from the direct-acting piston or plunger hoist or lift. It consists of a high-duty air motor geared to a hoisting drum by a mechanical train giving the highest possible efficiency. Combined with this efficiency are moderate weight, extreme compactness, low head-room, absolute safety, perfect control, steadiness in operation, freedom from vibration, and the utmost simplicity and durability. The word "high-duty" exactly describes the "Imperial" Hoist.

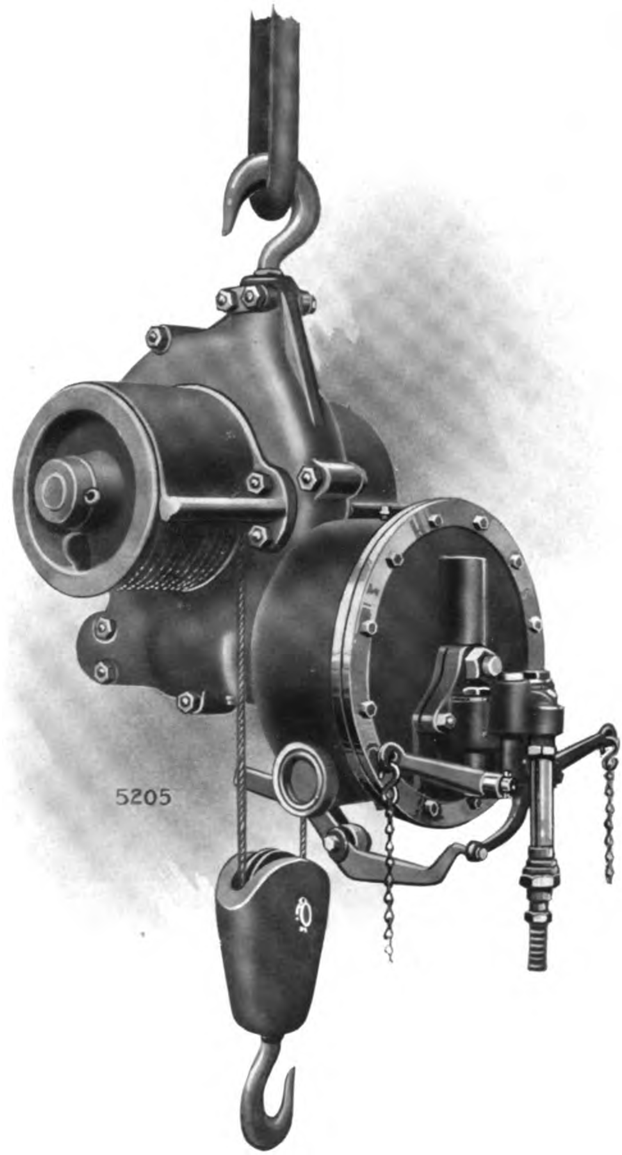
The Motor

The motor is of the standard type used on the well-known "Imperial" line of pneumatic drills and reamers. It is a balanced three-cylinder air engine operating with a lower air consumption per unit of power than any other pneumatic motor.

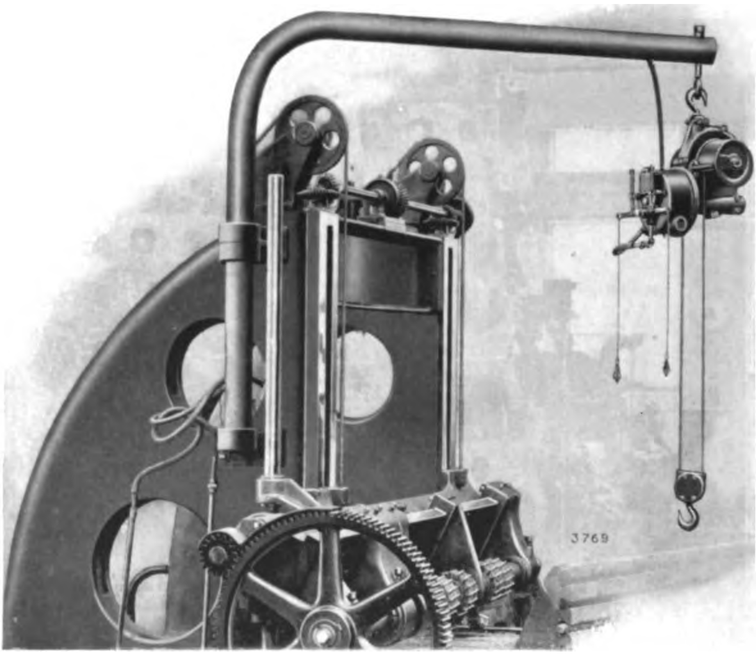
The machine is "valveless" in the sense that no separate part is required for the control of the air admission and exhaust. Air is admitted and discharged through ports in the crank, which is of large diameter and so designed that all ports and passages are shorter than in any other piston motor. The three radial cylinders are bored from a rough casting and rotate about the crank. Their bearing is bushed with a taper bronze sleeve, wear on which is taken up by simply driving up on the taper. Since the thrust of the pistons is always outward, and pressure always exerted between piston and cylinder heads, the cylinders are always forced to a tight seat on the crank, and leakage of live air is practically impossible. The exceptionally short ports, and this precaution against leakage of live air, are two important factors in reducing the air consumption of the "Imperial" Motor Hoist below that of any other.

Bearings

All motor parts are of superior materials, steel being largely used except for such parts as bushings and pistons, which are of the best phosphor bronze. The motor and gear casing are of cast iron. Every bearing has a removable bushing, and wear can be made good by simply substituting a new bushing for a worn one. There are no "steel-on-steel" bearings, and no other motor is so completely bushed throughout. The frames run on ball bearings of large diameter, with removable ball runs flooded with oil.



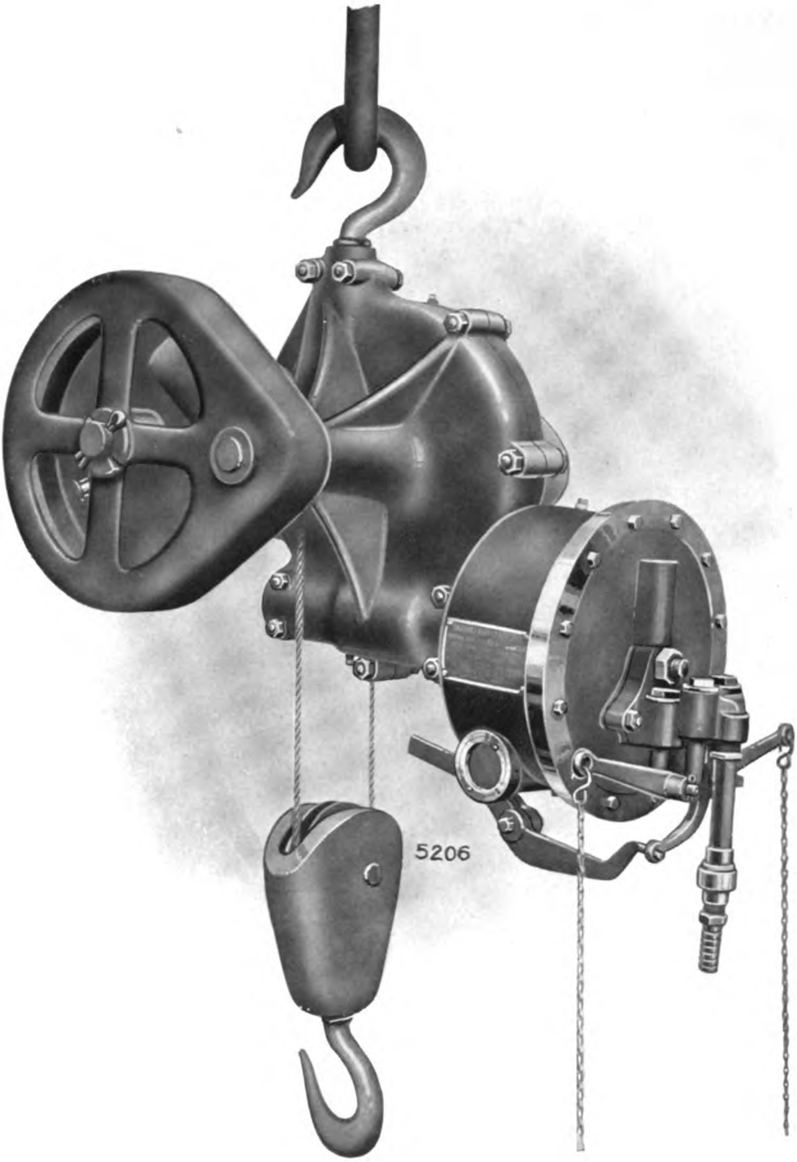
Standard "Imperial" Motor Hoist, Nos. 1 and 2



One of Several "Imperial" Motor Hoists at the Bullock Electric Company's Plant, East Norwood, Ohio

Gearing

The worm gearing on the "Imperial" Hoist between motor and rope drum maintains the same high standard of efficiency and durability that marks the motor itself. In all sizes it is wholly enclosed in a dust-proof and oil-tight casing. Its bearings are bushed with removable phosphor bronze bushings. In the two smaller sizes, Nos. 1 and 2, there is but one speed reduction between motor and drum shaft, consisting of an accurately cut worm and wheel. In the larger sizes, Nos. 4, 7 and 10, two speed reductions are used. The first is through a worm and wheel, the second through an accurately cut spur gear and pinion. The worm, driven directly from the motor shaft, is of high-carbon steel and meshes with a bronze worm wheel of large diameter. This worm gearing is of the high-speed type, running in a bath of oil. Tests have repeatedly shown a mechanical efficiency of over eighty per cent, at once removing all objections which have heretofore held against worm



Standard "Imperial" Motor Hoist, No. 4

gearing on the grounds of inefficiency. The thrust in the worm is taken up on a ball bearing. The hoisting drums are machine grooved and there is no wear on the pliable wire rope used.

Lubrication

No other hoist is so completely lubricated as the "Imperial." The motor casing is partially filled with oil, which, with the machine in operation, is flooded over every part. A glass-covered opening in the motor casing indicates the oil level. Every bearing runs in a literal bath of oil, so that wear is practically eliminated. Since there is no air pressure on the inside of the casing, there is no tendency to blow or force out the oil. Even the exhaust air is excluded from the casing, so there is no opportunity to dry out the bearings or carry off the lubricant. This is an exclusive feature of the utmost importance in its effect upon good wearing qualities. The "Imperial" Hoist is cleanly, for its exhaust does not throw oil over its surroundings.

The Operating Valve

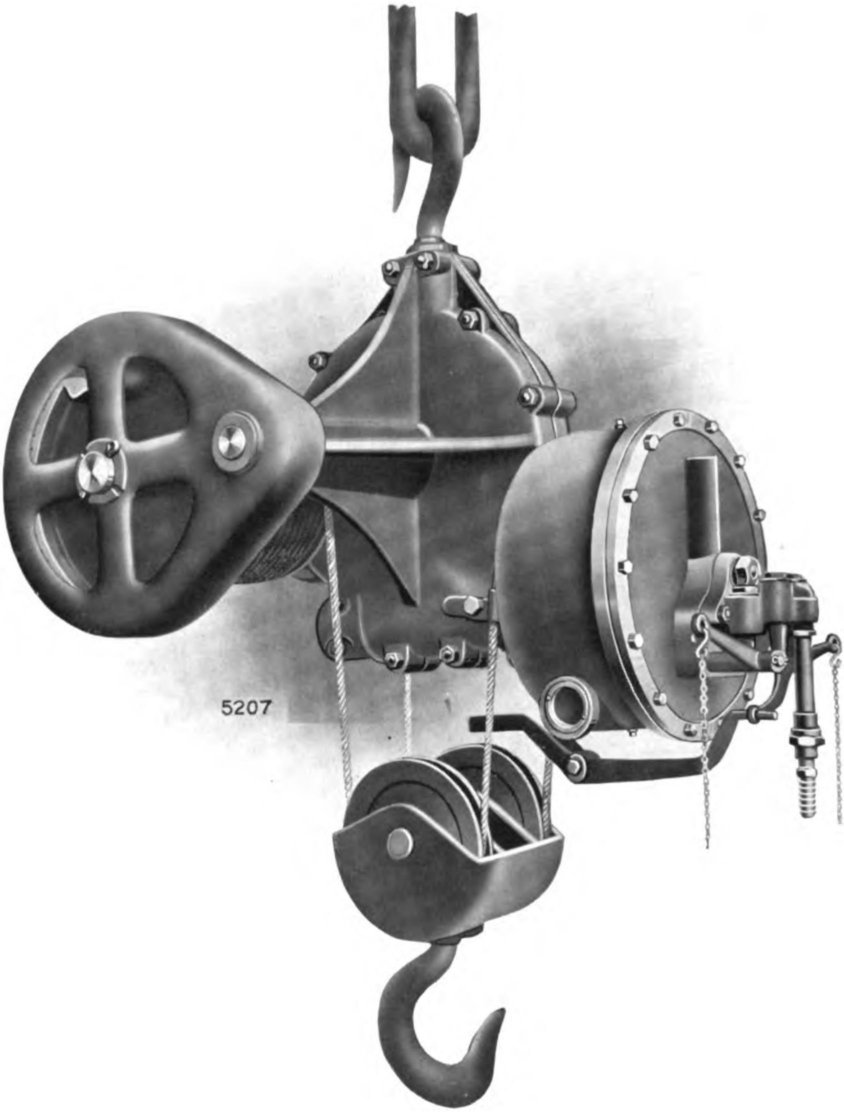
The operating valve is of the self-centering reversing type, automatically returning to closed position when the chains are released. The controlling chains reach to the floor when the hoist is at a height to provide for the maximum lift. The speed of the hoist is under ready and instant control and is capable of being varied within wide limits.

The Hook Blocks

The ball-bearing lower hook block is another exclusive feature of the "Imperial" Motor Hoist. The rope runs over a groove providing compensation on the two drums. As the hook turns on ball bearings, the load may be turned in any direction without twisting the hoisting ropes. More than this, the load will stay in any position in which it is turned without swinging back, — a feature provided on no other hoist, and which will be appreciated by all those having hoisting problems requiring delicate adjustment of load.

Freedom from Vibration

One of the greatest advantages of the "Imperial" Motor Hoist is its steadiness in action and its absolute freedom from vibration. The motor, being balanced, runs without vibration at all speeds. The worm transmits its motion with perfect uniformity to the gears, and these to the drums. The result is an absolutely steady, uniform



Standard "Imperial" Motor Hoist, Nos. 7 and 10

lift, with no jerks, jars or vibration whatever. The operation of the "Imperial" Hoist, in this respect, is in direct contrast to that of the ordinary spur-geared or direct-acting hoist.

This vibrationless feature is of special value in foundry work where heavy copes are to be lifted, transferred, swung and lowered without jarring out the sand. The "Imperial" is the only hoist which has satisfactorily met the delicate conditions of foundry hoisting.

The ball-bearing hook block is another feature of great value in this work, as it permits a cope to be turned and accurately adjusted in lowering, with no jerks and with no twisting of the ropes.

No Brake Required

The "Imperial" Hoist requires no brake, and is the only hoist on the market with this valuable feature. The function of the brake is performed by the worm gear which absolutely prevents any running back of the drums under load; and the gear instantly and positively locks, whether in hoisting or lowering, the moment the motor stops. There is not the slightest possibility of slipping or back-lash, even should air pressure suddenly fail. No brake can be so positive as this locked gear. Moreover, any brake soon loses its effectiveness under wear and the presence of oil on the friction surfaces. There can be no deterioration in the locking quality of the worm gear.

The Automatic Stop

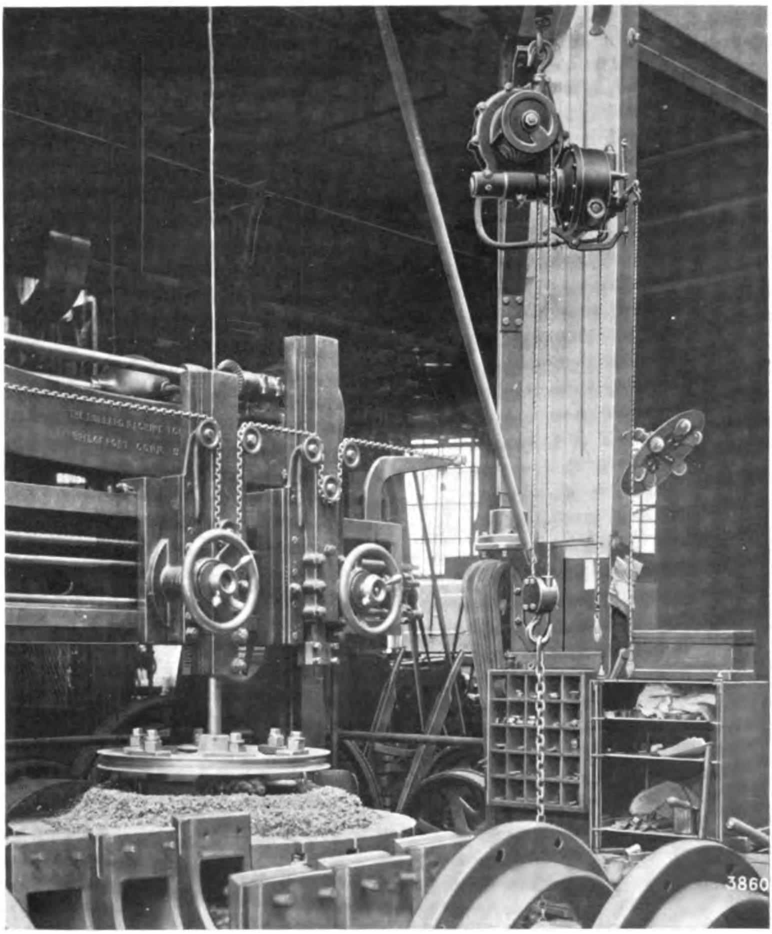
An automatic stop is provided on the "Imperial" Hoist which closes the throttle when the load has been raised to the top of its lift. This little refinement prevents injury to the hoist through the carelessness or neglect of the operator.

Construction Details

In every detail the design, workmanship and materials of the "Imperial" Motor Hoist are of the highest standard of excellence. Steel parts are hardened or toughened, as the case may be, where experience has shown such treatment to be desirable. The machines are built in a highly organized shop devoted exclusively to the manufacture of small pneumatic tools, and by workmen specially skilled in this exacting class of work. All parts are strictly interchangeable and duplication is guaranteed. The finished product is a hoist

which is light, compact, powerful, economical and reliable, and unequaled in the refinement of its control and operation.

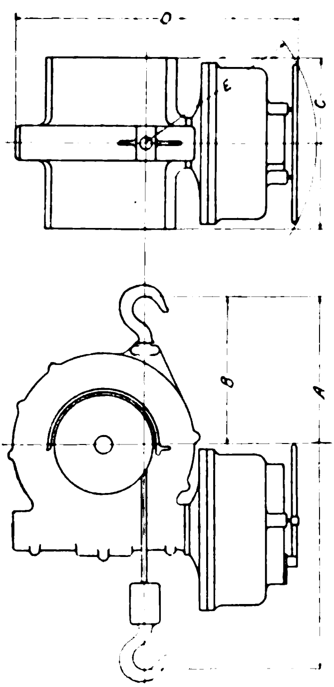
The "Imperial" Motor Hoist is built in five sizes, having capacities of ½, 1, 1½, 3½ and 5 tons, all with a standard lift of twenty feet. Important facts about the "Imperial" Motor Hoist are tabulated on the following page.



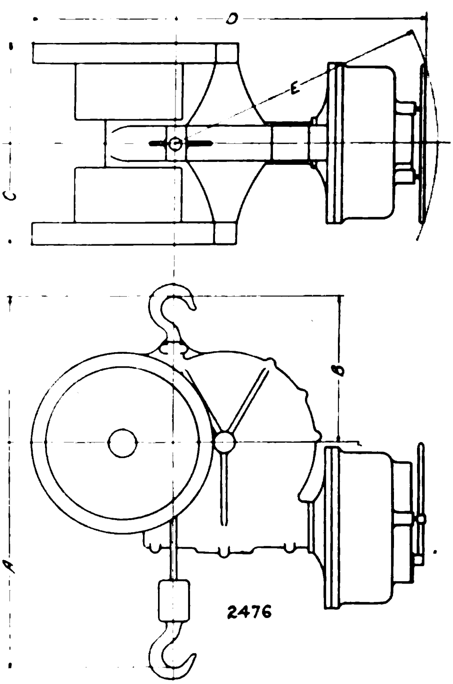
Serving a Machine Tool in One of the Plants of the Otis Elevator Company

"IMPERIAL" MOTOR HOISTS

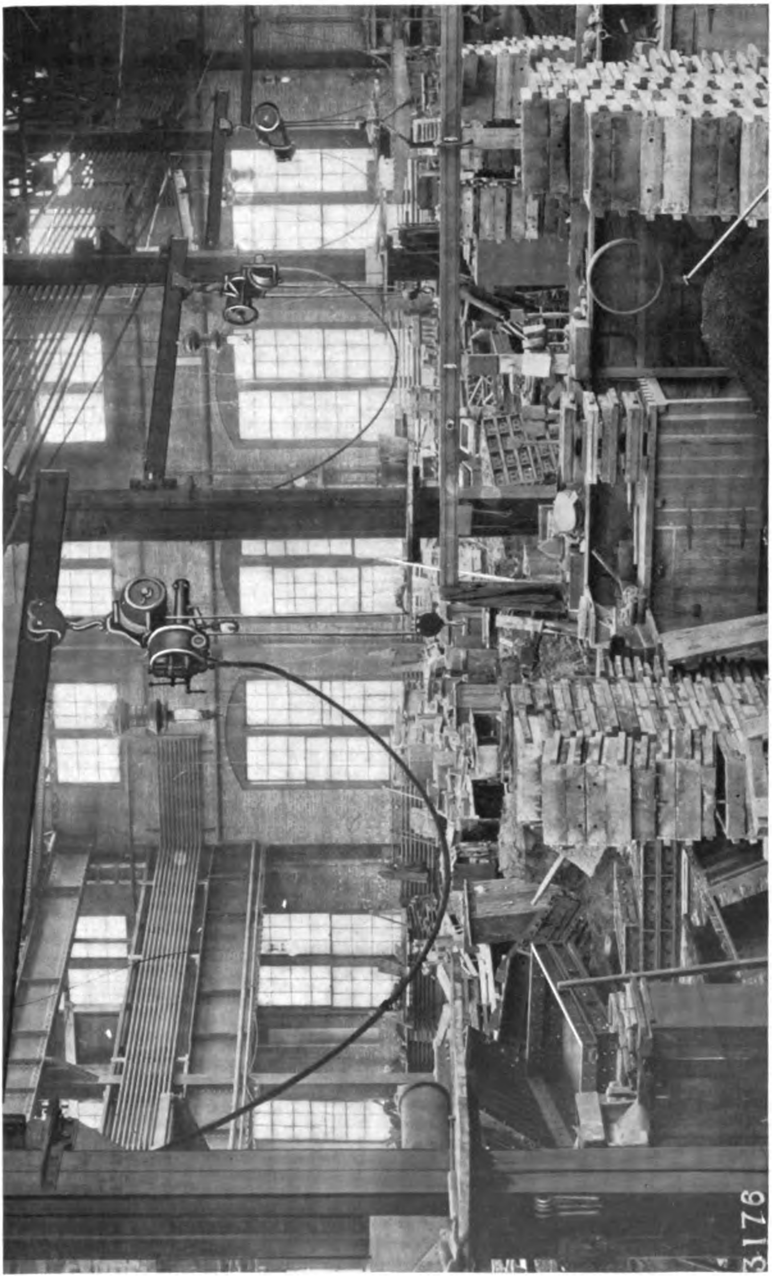
Size No.	Capacity in lbs.	Ft. Lift Per Minute 80 lbs. Pres.	Maximum Lift Ft.	Size and Length Wire Rope ins. x ft. & ins.	Size Motor	Cu. Ft. Free Air Per Min.	Net Weight Pounds	Weight Boxed Pounds	Cu. Ft. Boxed	Dimensions Inches A	B	C	D	E
1	1000	32	20	¼"x42' 10"	4	45	270	324	10¾"	32½"	12⅛"	17½"	24¾"	16¾"
2	2000	16	20	¼"x42' 10"	4	45	270	324	10¾"	32½"	12⅛"	17½"	24¾"	16¾"
4	4000	8	20	5/16"x42' 10"	4	45	395	474	13⅛"	40"	13⅛"	20¾"	32¼"	24¾"
7	7000	8	20	⅜"x96' 6"	5	80	785	942	27¾"	46¾"	18¾"	29½"	39⅝"	21⅝"
10	10000	7	20	⅜"x96' 6"	5	80	785	942	27¾"	46¾"	18¾"	29½"	39⅝"	21⅝"



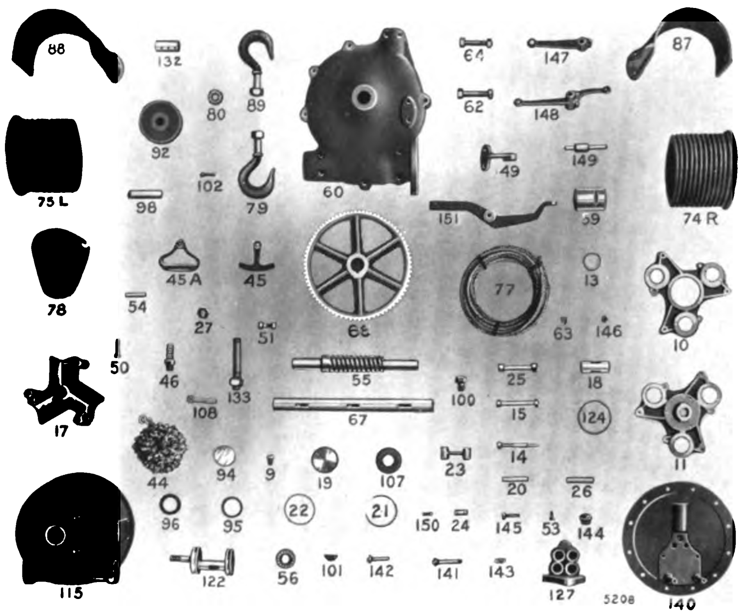
Nos. 1 and 2 Hoists



Nos. 4, 7 and 10 Hoists

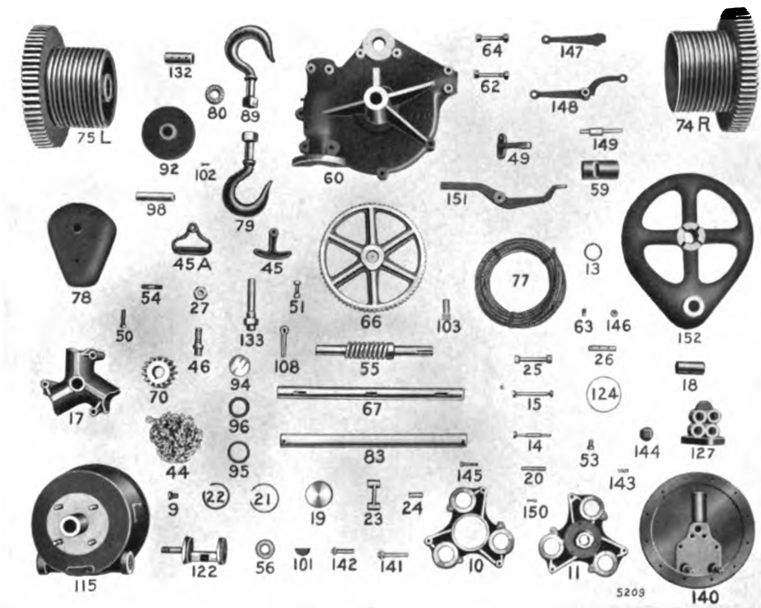


"Imperial" Motor Hoists in the Shops of the Pratt & Whitney Co., Hartford, Conn.



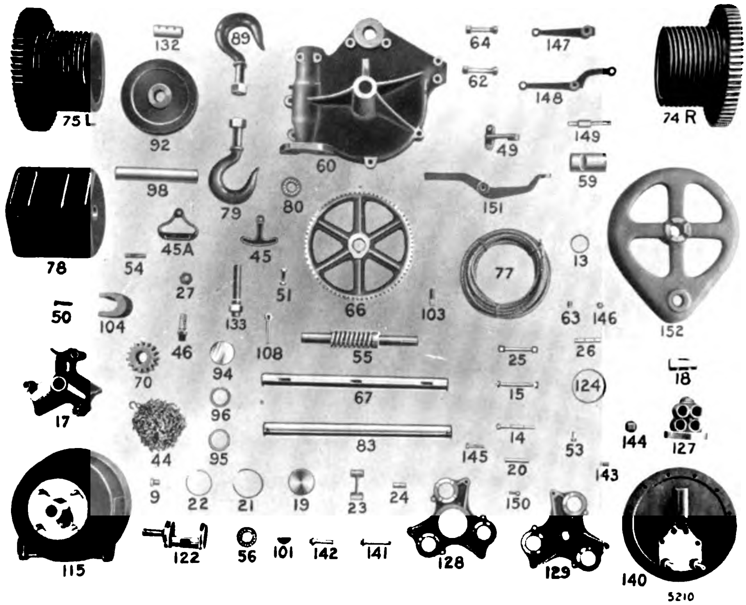
"Imperial" Hoists Nos. 1 and 2 Duplicate Part List

No.	Name of Part
9	Crank Disc Key
10	Guide Frame
11	Drive Frame
13	Frame Bushing
14	Frame Bolt
15	Frame Separator
17	Cylinder
18	Cylinder Bushing
19	Piston
20	Piston Pin
21	Piston Packing
22	Piston Spring
23	Connecting Rod
24	Rod Bushing
25	Roller
26	Roller Bushing
27	Crank Nut
44	Operating Chain
45	Operating Chain Handle (raise)
45A	Operating Chain Handle (lower)
46	Hose Nipple
49	Stop Lever Fulcrum
50	Fulcrum Screw
51	Fulcrum Bolt and Nut
53	Motor Case Cover Screw
54	Motor Case to Gear Case Stud
55	Worm
56	Worm Thrust Bearing
59	Worm Cap
60	Gear Case
62	Gear Case Bolt (long)
63	Oil Hole Plug
64	Gear Case Bolt (short)
66	Worm Gear
67	Worm Gear Shaft
74R	Rope Drum (right)
75L	Rope Drum (left)
77	Rope
78	Bottom Hook Block
79	Bottom Hook
80	Bottom Hook Thrust Bearing
87	Rope Guard (right)
88	Rope Guard (left)
89	Top Hook
92	Bottom Hook Sheave
94	Sight Glass
95	Sight Glass Retainer
96	Sight Glass Packing
98	Bottom Hook Sheave Shaft
100	Rope Guard, Tap Bolt
101	Drum Key
102	Sheave Shaft Cotter
107	Drum Shaft Collars
108	Worm Gear Shaft Cotter
115	Motor Case
122	Crank
124	Frame Ball Cup
127	Valve Chest
132	Worm Cap Bushing
133	Hose Connection
140	Motor Case Cover
141	Live Air Valve
142	Exhaust Valve
143	Exhaust Valve Spring
144	Valve Cap
145	Valve Chest Bolt
146	Valve Chest Bolt Nut
147	Throttle Lever (left)
148	Throttle Lever (right)
149	Throttle Lever Pin
150	Throttle Lever Pin Cotter
151	Stop Lever



"Imperial" Motor Hoist No. 4 Duplicate Part List

No.	Name of Part
9	Crank Disc Key
10	Guide Frame
11	Drive Frame
13	Frame Bushing
14	Frame Bolt
15	Frame Separator
17	Cylinder
18	Cylinder Bushing
19	Piston
20	Piston Pin
21	Piston Packing
22	Piston Spring
23	Connecting Rod
24	Rod Bushing
25	Roller
26	Roller Bushing
27	Crank Nut
44	Operating Chain
45	Operating Chain Handle (raise)
45A	Operating Chain Handle (lower)
46	Hose Nipple
49	Stop Lever Fulcrum
50	Fulcrum Screw
51	Fulcrum Bolt and Nut
53	Motor Case Cover Screw
54	Motor Case to Gear Case Stud
55	Worm
56	Worm Thrust Bearing
59	Worm Cap
60	Gear Case
62	Gear Case Bolt (long)
63	Oil Hole Plug
64	Gear Case Bolt (short)
66	Worm Gear
67	Worm Gear Shaft
70	Worm Gear Shaft Pinion
74R	Rope Drum (right)
75L	Rope Drum (left)
75	Rope
78	Bottom Hook Block
79	Bottom Hook
80	Bottom Hook Thrust Bearing
83	Drum Shaft
89	Top Hook
92	Bottom Hook Sheave
94	Sight Glass
95	Sight Glass Retainer
96	Sight Glass Packing
98	Bottom Hook Sheave Shaft
101	Drum Key
102	Sheave Shaft Cotter
103	Drum Shaft Set Screw
108	Worm Gear Shaft Cotter
115	Motor Case
122	Crank
124	Frame Ball Cup
127	Valve Chest
132	Worm Cap Bushing
133	Hose Connection
140	Motor Case Cover
141	Live Air Valve
142	Exhaust Valve
143	Exhaust Valve Spring
144	Valve Cap
145	Valve Chest Bolt
146	Valve Chest Bolt Nut
147	Throttle Lever (left)
148	Throttle Lever (right)
149	Throttle Lever Pin
150	Throttle Lever Pin Cotter
151	Stop Lever
152	Gear Guards



"Imperial" Motor Hoists Nos. 7 and 10
Duplicate Part List

No.	Name of Part
9	Crank Disc Key
13	Frame Bushing
14	Frame Bolt
15	Frame Separator
17	Cylinder
18	Cylinder Bushing
19	Piston
20	Piston Pin
21	Piston Packing
22	Piston Spring
23	Connecting Rod
24	Rod Bushing
25	Roller
26	Roller Bushing
27	Crank Nut
44	Operating Chain
45	Operating Chain Handle (raise)
45A	Operating Chain Handle (lower)
46	Hose Nipple
49	Stop Lever Fulcrum
50	Fulcrum Screw
51	Fulcrum Bolt and Nut
53	Motor Case Cover Screw
54	Motor Case to Gear Case Stud
55	Worm
56	Worm Thrust Bearing
59	Worm Cap
60	Gear Case
62	Gear Case Bolt (long)
63	Oil Hole Plug
64	Gear Case Bolt (short)
66	Worm Gear
67	Worm Gear Shaft
70	Worm Gear Shaft Pinion
74R	Rope Drum (right)
75L	Rope Drum (left)
77	Rope
78	Bottom Hook Block
79	Bottom Hook
80	Bottom Hook Thrust Bearing
83	Drum Shaft
89	Top Hook
92	Bottom Hook Sheave
94	Sight Glass
95	Sight Glass Retainer
96	Sight Glass Packing
98	Bottom Hook Sheave Shaft
101	Drum Key
102	Sheave Shaft Cotter
103	Drum Shaft Set Screw
104	Bottom Hook Block Lock
108	Worm Gear Shaft Cotter
115	Motor Case
122	Crank
124	Frame Ball Cup
127	Valve Chest
128	Guide Frame
129	Drive Frame
132	Worm Cap Bushing
133	Hose Connection
140	Motor Case Cover
141	Live Air Valve
142	Exhaust Valve
143	Exhaust Valve Spring
144	Valve Cap
145	Valve Chest Bolt
146	Valve Chest Bolt Nut
147	Throttle Lever (left)
148	Throttle Lever (right)
149	Throttle Lever Pin
150	Throttle Lever Pin Cotter
151	Stop Lever
152	Gear Guards

"IMPERIAL" STATIONARY AIR MOTORS

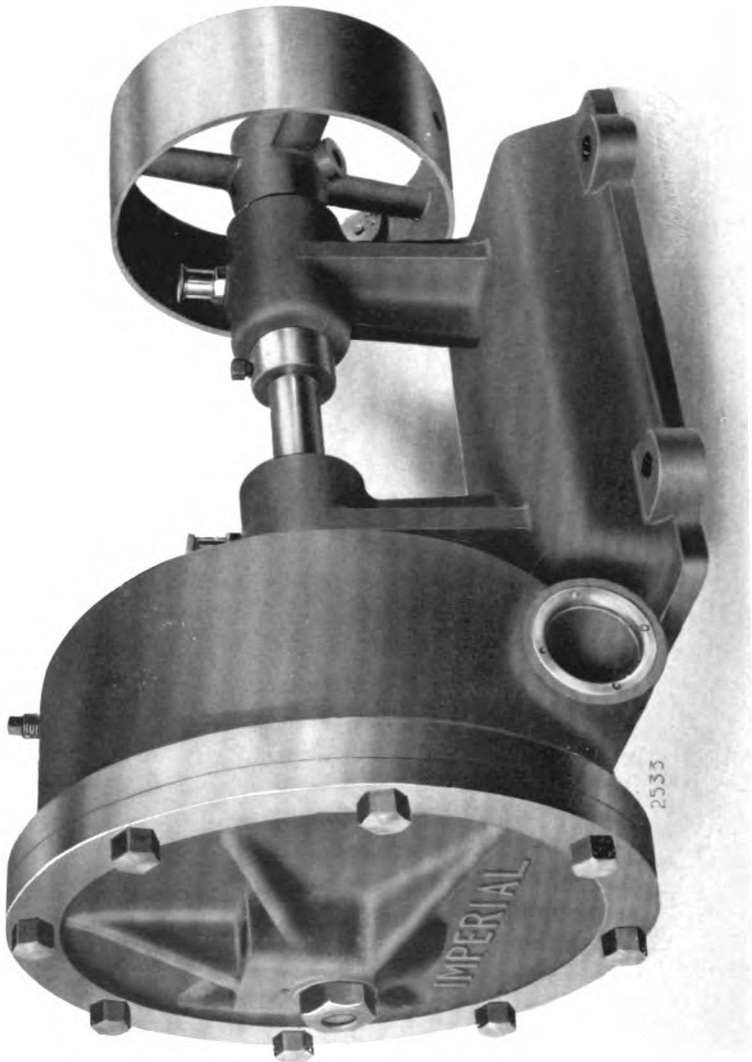
In many fields there is a growing demand for motors of small power, good economy and satisfactory reliability, to be used for isolated and intermittent service without skilled attendance. Instances of such work are: the operating of small tools or cranes, in shop, foundry, freight yard, warehouse, stone yard and quarry; the driving of small chain or rope drums, winches, small lines of shafting; operating emery, buffing and polishing wheels, fans, etc.

This work demands a motor which shall be ready for duty on a moment's notice, which will not deteriorate under hard service, which will continue to do good work with little attention, which will combine power with extreme compactness, which will demand no expert skill in installation, and the presence of which will not endanger the safety of the plant or of the operator.

No device so well meets these requirements as the "Imperial" Stationary Motor. Its advantages recommend it above all others for plants where compressed air is already present for other purposes. But its acknowledged superiority has in some cases led to the installation of a compressor plant especially for its operation.

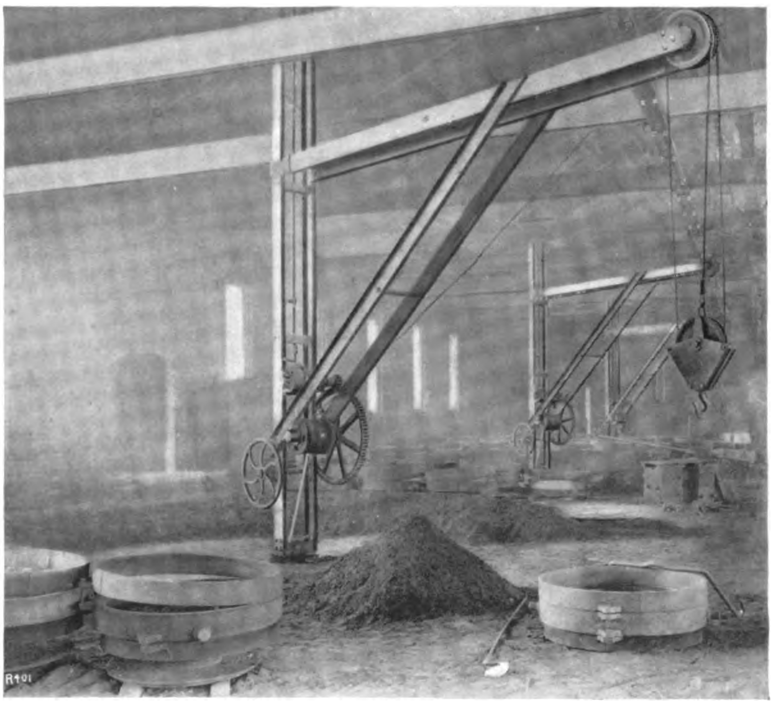
The "Imperial" Motor is a powerful, compact, simple and economical machine requiring the minimum of attention. The motor itself is identical in design and construction with that used in the "Imperial" Hoist, already described in the previous pages of this bulletin. It is wholly enclosed in a dust-proof, oil-tight casing, and is lubricated by the splash system. This casing is mounted on a base which also carries the pulley and shaft bearings, of ample diameter and length. The motor may be mounted on floor, wall or post, or otherwise attached as may be most convenient. Either a pulley or gear may be used on the shaft.

The "Imperial" Motor is furnished in two sizes only, rated at 2 and 3¼ horse-power. The speeds, air consumption and dimensions are tabulated on page 18. Standard motors are non-reversible, but they can be furnished reversible on order, at extra cost.

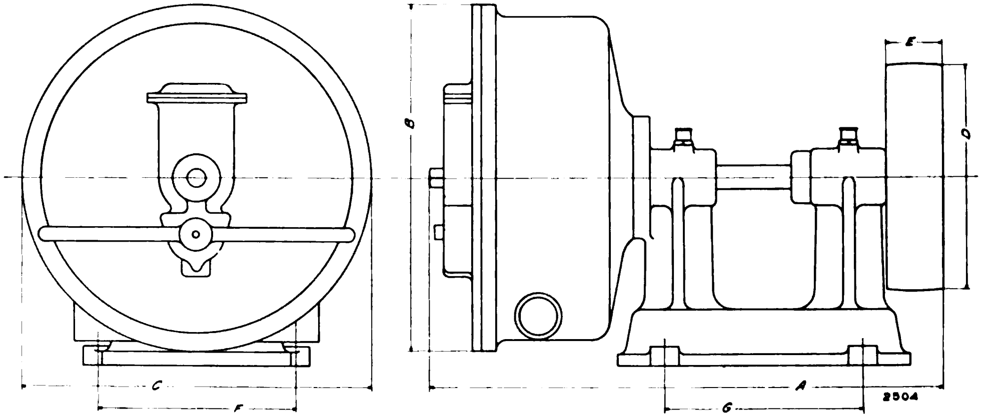


Standard "Imperial" Stationary Motor, Nos. 4 and 10

It should be definitely understood that these motors are not intended for heavy, continuous duty, nor for use with steam. A consideration of prime importance in their design has been the keeping of dimensions and weight at the lowest practical limit. Evidently these considerations forbid as large a factor of safety in their construction as is required in a machine intended to carry its load continuously. The "Imperial" Motor is not intended for such service. But for intermittent work, such as that required in such cases as those already mentioned, no machine gives a better economy or more uniform satisfaction.

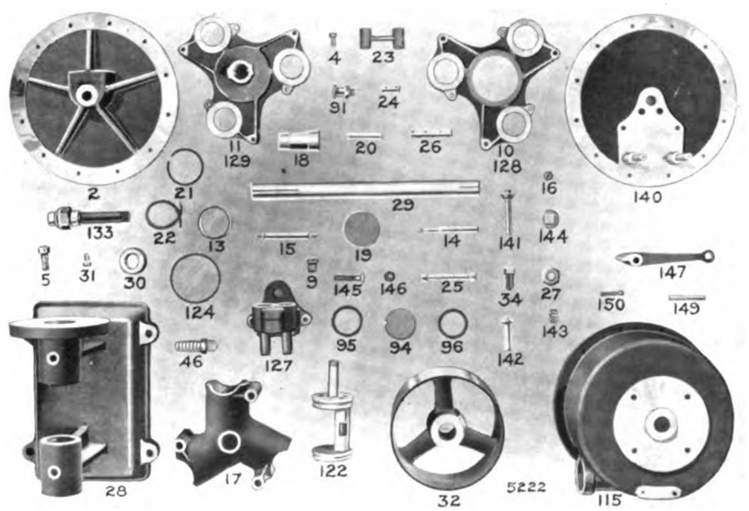


"Imperial" Stationary Motor on a Jib Crane for Foundry Work. Twelve in use at the Shops of the National Car Wheel Co., Sayre, Pa.



"IMPERIAL" STATIONARY MOTORS

Size	H. P.	Speed R. P. M.	Cu. Ft. Free Air Per Min	Weight Pounds	Dimensions Inches						
					A	B	C	D	E	F	G
4	2	750	45	129	22⅞	13⅛	12⅛	8	3	8½	8½
10	3¼	750	80	230	27⅝	17	16	12	4	10½	10½



"Imperial" Stationary Motors Nos. 4 and 10 Duplicate Part List

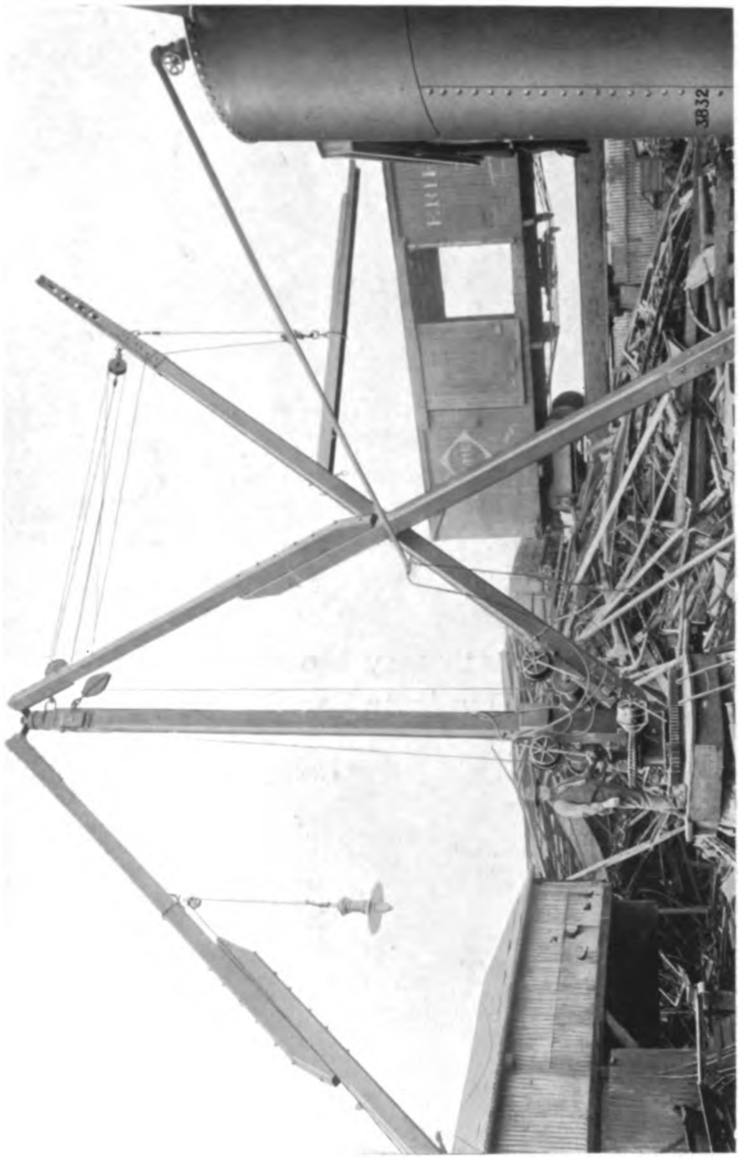
No.	Name of Part
2	Motor Case Cover
4	Motor Case Cover Screws
5	Case to Base Screws
9	Crank Disc Screws
10	Guide Frame (No. 4 Motor only)
11	Drive Frame (No. 4 Motor only)
13	Frame Bushing
14	Frame Bolt
15	Frame Separator
16	Frame Bolt Nut
17	Cylinder
18	Cylinder Bushing
19	Piston
20	Piston Pin
21	Piston Spring
22	Piston Packing
23	Connecting Rod
24	Rod Bushing
25	Rollers
26	Roller Bushing
27	Crank Nut
28	Motor Base
29	Pulley Shaft
30	Shaft Collar
31	Shaft Collar Set Screw

No.	Name of Part
32	Pulley
34	Pulley Set Screw
91	Oil Cup
94	Sight Glass
95	Sight Glass Retainer
96	Sight Glass Packing
115	Case
122	Crank
124	Frame Ball Cup
128	Guide Frame (No. 10 Motor only)
129	Drive Frame (No. 10 Motor only)

The following parts are used on the reversible motor only:

No.	Name of Part
127	Valve Chest
133	Hose Connection
140	Motor Case Cover
141	Live Air Valve
142	Exhaust Valve
143	Exhaust Valve Spring
144	Valve Cap
145	Valve Chest Bolt
146	Valve Chest Bolt Nut
147	Throttle Lever
149	Throttle Lever Pin
150	Throttle Lever Pin Cotter

Nos. 10 and 11 answer the purpose for both 10 and 11 and 128 and 129, respectively, and are so numbered on cut.



"Imperial" Stationary Motors on Derrick for Handling Iron at Plant of American Iron and Steel Co., Lebanon, Pa.

Griffith-Stillings Press

"CROWN"

BENCH AND FLOOR

SAND RAMMERS

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Form No. 8108 May, 1910

4564

Standard "Crown" Floor and Bench Rammers

THE pneumatic sand rammer for foundry and concrete work is one of those labor-saving devices which has made a permanent place for itself, even against strong opposition, on the grounds of economy, lower production cost, larger output and

Three "Crown" Floor Sand Rammers at Work on a Large Flask

improved quality of product which follow its use. It is rapidly taking its place with the penumatic hammer and drill as an industrial necessity.

Lower Cost of Castings

In the foundry the cost of power for operating one of these machines does not begin to compare with the labor saving effected by its use. Compressed air is usually available, and the added air consumption of a "Crown" Sand Rammer is practically negligible. But the savings made possible by its use justify the installing of an air compressor to operate it, even if one is not present; and the air is then available for hammers, hoists, sand blasts, etc.

The following figures show the result of some observations made in representative foundries all over the country. They are not merely "test" figures, but show what can be accomplished with the pneumatic sand rammer under everyday working conditions.

Size of Cope	Time in Peining and Ramming		Ratio of Reduction	Per Cent Time Saved
	By Hand	By Sand Rammer		
12′ x 18″ x 4″	5 min.	1 min.	1:5	80
12′ x 18″ x 10″	10 min.	1½ min.	1:6.6	85
6′ x 3′ x 6″	20 min.	3 min.	1:6.6	85
6′ x 6′ x 8″	35 min.	8 min.	1:4.4	77
8′ x 6″ x 6″	1 hour	10 min.	1:6	83
7′ x 3′ x 12″	1 hr. 30 min.	16 min.	1:5.6	82
15′ x 30″ x 16″	2 hours	27 min.	1:4.4	77
12′ x 7′ x 16″	2 hr. 12 min.	34 min.	1:3.9	74
87″ x 159″ x 10″	4 hours	40 min.	1:6	83
19′ x 90″ x 15″	8 hours	1 hr. 30 min.	1:5.3	81

It is to be especially noted that these figures include not only the final ramming, but the more careful peining as well; and the total time covers the completed job. In another instance a pulley 78 inches in diameter with a 24-inch face was peined and rammed complete in three hours.

These results, showing a ratio of advantage of machine over hand ramming varying from 1:3.9 up to 1:6.6, and a time saving of 74 to 85 per cent may be considered fairly representative of the reduction in time and labor cost to be effected by "Crown" Sand Rammers where intelligently used in average foundry work.

"Crown" Floor Sand Rammer (Type "20-SR")

Improved Castings

Another great advantage to be derived from the use of "Crown" Rammers lies in the fact that they produce better castings. The flasks are rammed much harder and more uniformly than is possible by hand. "Straining" in the mould, with the resultant loss of metal, may be eliminated. The better, more uniform machine ramming produces castings true to pattern, uniform in weight and quality. This avoids costly "overweight" castings and materially reduces the total cost of metal in cases where large numbers of castings are to be made from a single pattern.

The fact that these machines have been adopted in some of the largest and best organized foundries in the country is confirmation of all claims in their favor. But they are equally advantageous in the small foundry.

In Concrete Work

The increasing use of concrete in the production of building blocks, architectural forms, sewer pipe, etc., has developed another field in which the pneumatic sand rammer has demonstrated its value and economy. In this work its advantages over hand ramming are probably in the same proportion as just stated in foundry work. Lower labor cost, greater rapidity of work, larger output, and a product of uniform quality and distinct superiority — these follow the use of this machine in ramming concrete into moulds. The increasing demand for concrete forms equal to the most severe tests makes it incumbent upon the makers to produce a material which will stand the closest scrutiny, and the pneumatic sand rammer is one of the chief factors in attaining this result.

In permanent concrete construction in massive form — such as bridge and pier construction, paving, retaining walls, abutments, foundations, etc. — this machine produces an unusually solid, rock-like concrete of the highest quality.

"Crown" Sand Rammers

The "Crown" Sand Rammer takes its name from the fact that it uses the well-known Ingersoll-Rand "Crown" valve, used with such success in the "Crown" chipping and riveting hammers. This is a hardened steel spool valve, working under unbalanced air

pressure in a hardened steel valve box clamped between the cylinder and the head block of the tool. The valve mechanism is entirely enclosed and protected against dirt, a screen being interposed between the air inlet and valve mechanism.

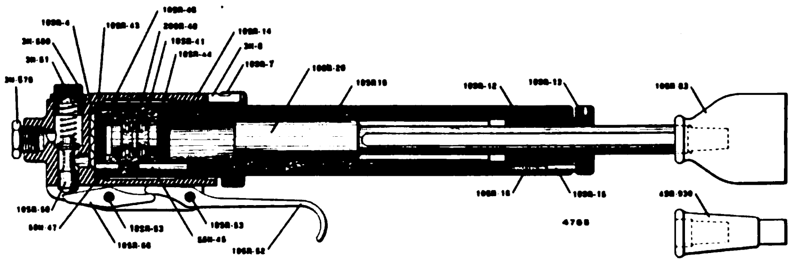
The cylinder is of a special steel, hardened and ground in the bore; and the piston is hardened, with the rods left tough. Steel parts are oil treated and annealed. Two flats milled on the rod prevent the turning of the piston in the cylinder and the rotation of the butt or pein. The weight is carefully adjusted so that there is the minimum of jar or reaction in running. The blows are very sharp and rapid, and their number and force under complete control by the throttle.

The "Crown" Bench Rammer (Type 10-SR) is a small machine weighing ten pounds and intended for working on small flasks such as are ordinarily handled on the bench. It is also used for core work.

The "Crown" Floor Rammer (Type 20-SR) is a longer, heavier tool, weighing about twenty-two pounds and intended for larger flasks upon which the man works standing.

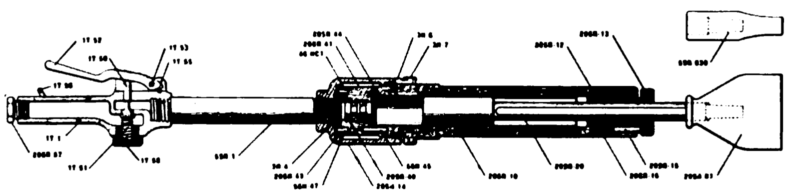
The price of a complete rammer covers the tool bare (without hose) including the throttle, one round butt and one pein. The two latter parts fit on the piston rod on a taper. The complete specifications of the "Crown" Bench and Floor Rammers are given below.

Description	Bench Rammer	Floor Rammer
Symbol	10-SR	20-SR
Cylinder Bore	1 inch	1¼ inches
Piston Stroke	4 inches	5 inches
Size of Butt	2½ in. diam.	3½ in. diam.
Size of Pein	⅝ in.x2¼ in.	¾ in. x 3 in.
Free Air Consumption at 40 lbs. pressure—in cubic ft. per min.	12	12
" " " " 50 " " " " " " "	14½	15
" " " " 60 " " " " " " "	17	18
" " " " 70 " " " " " " "	19½	21
" " " " 80 " " " " " " "	22	24½
" " " " 90 " " " " " " "	25	28
" " " " 100 " " " " " " "	28	32
Approximate Number of Blows per minute under 80 pounds air pressure, throttle wide open	750	600
Weight, unboxed	10 pounds	22½ pounds
Length over all	20 inches	46 inches
Telegraph Name	Halsbanden	Halsbein



Duplicate Part List of "Crown" Bench Sand Rammer (Type "10-SR")

Part No.	Symbol	Name of Part	Part No.	Symbol	Name of Part
10	10SR	Cylinder	53	10SR	Throttle Lever Pin
6	3H	Cylinder Locking Key	56	10SR	Throttle Lever
7	10SR	Cylinder Locking Key Spring	570	3H	Nipple
12	10SR	Packing Washer	580	3H	Screw Plug
13	10SR	Packing Nut	41	10SR	Valve Box
15	10SR	Packing Nut Locking Pin	40	20SR	Valve
16	10SR	Packing Nut L'ck'g Pin Spring	43	10SR	Valve Box Top Cap
20	10SR	Piston	44	10SR	Valve Box Bottom Cap
14	10SR	Head Block	45	56H	Valve Box Bottom Dowel
4	10SR	Screen	46	10SR	Valve Box Cap Dowel
50	10SR	Throttle Valve	47	56H	Valve Box Top Dowel
51	3H	Throttle Valve Spring	83	10SR	Butt
52	10SR	Throttle Trigger	930	4SR	Pein



Duplicate Part List of "Crown" Floor Sand Rammer (Type "20-SR")

Part No.	Symbol	Name of Part	Part No.	Symbol	Name of Part
1	5SR	Handle	12	20SR	Packing Leather
1	1T	Throttle Valve Body	13	20SR	Packing Nut
50	1T	Throttle Valve	15	20SR	Packing Nut Locking Pin
51	1T	Throttle Valve Spring	16	20SR	Packing Nut Lock'g Pin Spring
52	1T	Throttle Lever	20	20SR	Piston
53	1T	Throttle Lever Pin	41	20SR	Valve Box
55	1T	Throttle Lever Stop Pin	40	20SR	Valve
56	1T	Throttle Lever Locking Ring	43	20SR	Valve Box Top Cap
57	20SR	Nipple	44	20SR	Valve Box Bottom Cap
58	1T	Screw Plug	45	56H	Valve Box Bottom Dowel
14	20SR	Head Block	46	HC-1	Valve Box Cap Dowel
4	3H	Screen	47	56H	Valve Box Top Dowel
10	20SR	Cylinder	83	20SR	Butt
6	3H	Cylinder Locking Key	930	5SR	Pein
7	3H	Cylinder Locking Key Spring			

The Care of "Crown" Sand Rammers

It is necessary to the satisfactory operation and durability of this tool that the working parts be kept well oiled and free from dirt and grit. To lubricate the tool pour a small quantity of clean, light machine oil in the air inlet before attaching the hose. This should be done every two hours when the tool is being used constantly. Light machine oil is good to use, but our special brand of VACUUM ARCTIC AMMONIA OIL is better. Do not use thick or gritty oil, as it will cause the working parts to cut or work sluggishly. The entire tool should be taken apart at least once a week, the parts washed in kerosene, carefully put together again and oiled.

Always keep the head block, Part 14, screwed tight to the cylinder, Part 10, so as to prevent leaking between the connecting surface of the head block, valve box and cylinder. If the head block becomes loose, remove key spring, Part 7, drive out key, Part 6, and tighten the head block until one of the notches in the end of it is in line with one of the slots in the collar on the cylinder; then insert the key and put the key spring over the collar, being sure to have the notch in the key spring fit over the end of the key nearest the head block.

When ordering duplicate parts always give the SIZE and NUMBER of the Rammer, both of which are stamped on the cylinder, and specify the NUMBER and NAME of parts wanted as given in list.

WHEN RETURNING RAMMER FOR REPAIRS SHIP TO OUR FACTORY AT EASTON, PA., AND MARK NAME AND ADDRESS ON EACH PACKAGE.

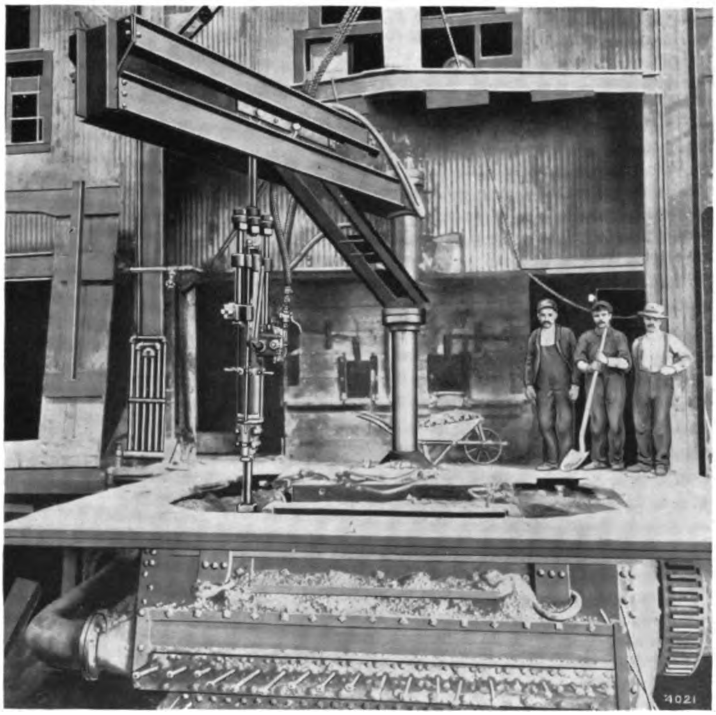
"Crown" Bench Sand Rammer at Work Preparing a Mould

GRIFFITH-STILLINGS PRESS, BOSTON

PNEUMATIC TAMPING MACHINES

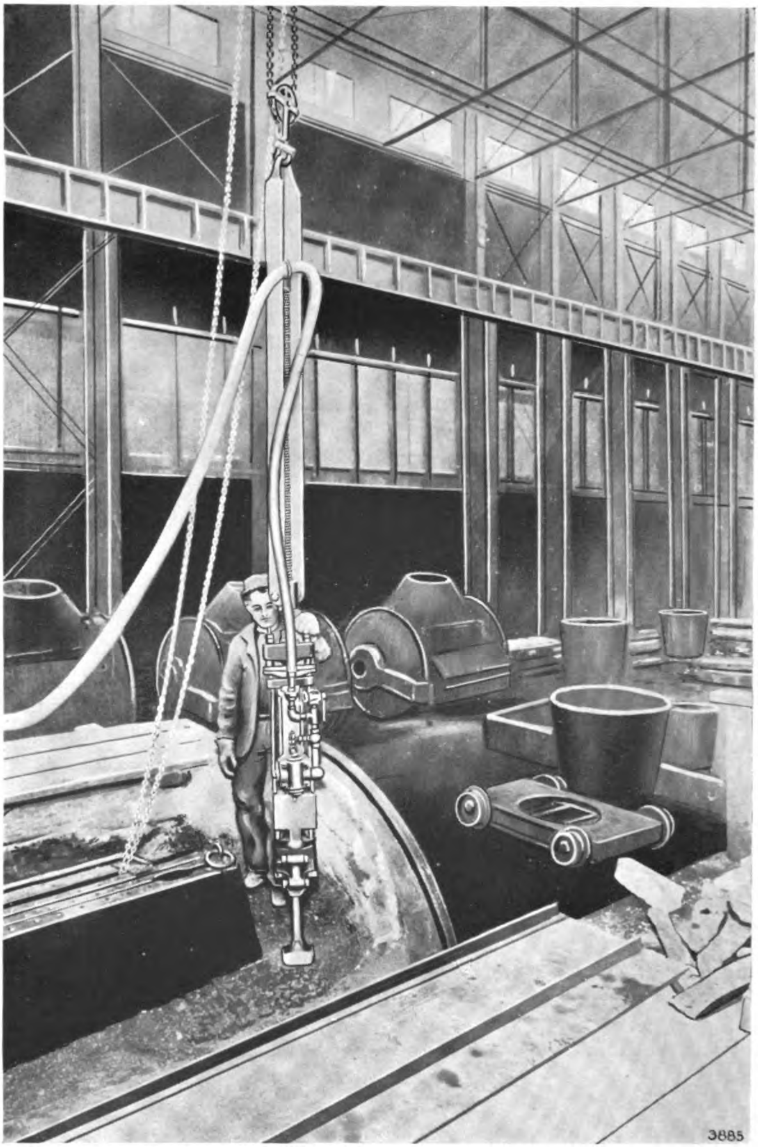
INGERSOLL-RAND COMPANY
11 BROADWAY, NEW YORK

Form No. 9008 December, 1910



"D-16" Tamping Machine in the Washoe Smelter, Butte, Montana

THE Ingersoll-Rand Pneumatic Tamping Machine is used in copper smelters to facilitate the re-lining of the copper converters used in the reduction of copper from its ores. It is a modification of one of the standard Ingersoll-Rand Rock Drill types and, being built in the Company's rock drill department, has all the care in design and construction, and all the rugged endurance, of the standard rock drill. The record made



"D-16" Tamping Machine with Feed-Screw in the Plant of the Butte Reduction Works

by Ingersoll-Rand Rock Drills is a guarantee of the ability of this machine to stand up under the most severe duty.

Copper converters are of various sizes, but the dimensions usually run from six to eight feet in diameter by seven to twelve feet in length. The intense heat to which they are subjected in the smelting process demands a very heavy lining of a heat-resisting, non-conducting material for protecting the metal parts of the converters.

The converter shell is given a lining of fire brick all around, about four inches in thickness. A metal form or core is then secured in the middle of the remaining space; and around this, inside the fire-brick lining, an interior lining of very refractory material is rammed or tamped. The core is then removed.

The substance composing this inner lining is a mixture of fire clay and silica, or a silicious ore, crushed, ground and mixed with water to the proper consistency. Sometimes a little lime is added as a binder. As the lining must be perfectly dry before the charge is smelted, the lining mixture is handled as dry as possible. This means that the necessary solidity must be secured by heavy ramming or tamping, rather than by using a mixture of a running consistency. This dry mixture takes less time to dry out—a process hastened by building a light fire inside the converter.

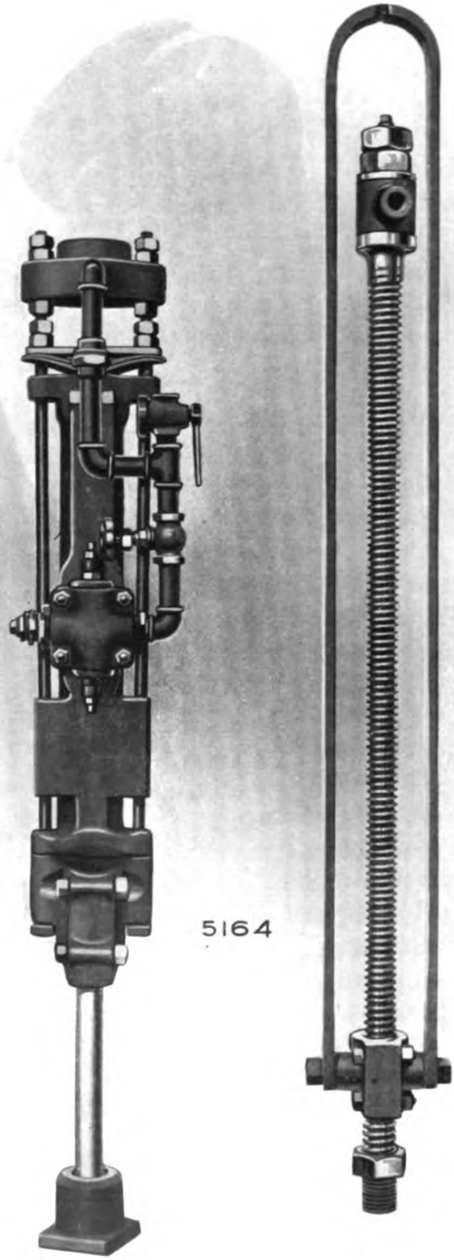
A newly lined converter is good for from three to nine charges before a new lining is required. Where a low grade matte is used, the converter must be re-lined oftener than where the matte is high grade.

The Economy of the Tamping Machine

The heavy, powerful blow of the Ingersoll-Rand Tamping Machine gives the necessary compactness to the lining with a very dry mixture. This means that the time during which the converter is idle while drying out is much reduced, increasing the yearly capacity of a given converter equipment.

Experience in one of the largest of the Montana copper smelters has shown that a 3⅛-inch Ingersoll-Rand Tamping Machine is equal in capacity to from six to ten men tamping by hand. A better lining is the result, as well.

In the same plant, a 5½-inch Ingersoll-Rand Tamping Machine was found to do the work of about three of the 3⅛-inch machines—a truly remarkable record when reduced



Standard "D-16" Tamping Machine, with Feed-Screw Shown Separate

to terms of man-capacity, representing the work of from eighteen to thirty men.

Observations in other smelters have shown practically the same results, so that these figures may be considered as fairly representative of the economies which may be expected from this machine. Practically every copper refining concern in the United States employing converters uses the Ingersoll-Rand Tamping Machine, with entire satisfaction.

Method of Suspension

The Pneumatic Tamping Machine is too heavy to be manipulated by hand and some method of suspension is required. The machine as furnished by the Company is complete in itself, ready to be connected to the means of suspension.

A jib crane is usually employed, the tamping machine being suspended on a carriage moving in and out on the crane arm. Vertical adjustment is provided by a chain block from which the machine hangs; or a long feed-screw is attached to the machine; or the jib crane itself is raised and lowered by a hydraulic or other device. The feed-screw gives the steadiest support and prevents the machine jumping about. A jib crane with an arm sufficiently long will cover two converters. Or, a traveling crane of jib or other type may cover a whole line of converters.

The Ingersoll-Rand Tamping Machine

The Pneumatic Tamping Machine of this Company is made in three sizes, for light, intermediate and heavy work, to be determined largely by the size of the converters to be handled. While complete details of sizes, weights, etc., are tabulated on another page, the following distinctions are to be noted.

The "D-16" machine has a 3⅛-inch diameter cylinder with a 12-inch stroke, and is furnished either with a feed-screw and hanger, with a feed-screw without hanger, or without either feed-screw or hanger.

The "F-16" machine has a 3½-inch cylinder diameter and a stroke of 12 inches, and is offered in the three modified forms as just described for the smaller size.

The "H-16" machine has a cylinder 5½ inches in diameter by 20-inch stroke, and is furnished only without feed-screw or

"D-16" and "H-16" Tamping Machines in the Omaha, Neb., Plant of the American Smelting and Refining Co.

In the Plant of the Old Dominion Copper Mining and Smelting Co., Globe, Ariz.

hanger, but with pads to which supporting gear can be fastened. This heavy machine should not be used except for very large converters where the lining mixture is sufficiently cohesive in character to remain in place and not be jarred loose from the bed by the heavy blows, after it has once been tamped in place.

In all sizes the length of stroke and the force of the blow are readily controlled by the operator, as well as the number of blows per minute. The ample length of stroke permits the tamping pad or foot-piece to be lifted well above the loose material dumped in for tamping. One of these machines will tamp the lining mixture practically as fast as it can be dumped into the

converter from the wheelbarrow. The lining can be tamped in much thicker layers by machine than by hand.

Air Consumption

The amount of air required by the Ingersoll-Rand Tamping Machine is practically negligible when compared with the saving of time and labor, and the reduction of idle time per converter, which it brings about. The following figures on air consumption are the result of tests and show what may be expected from a machine in good condition, the figures being in cubic feet of free air per minute.

Air	Symbol of Machine		
Pressure, Lbs.	"D-16"	"F-16"	"H-16"
80	90	100	130
90	100	113	145
100	112	127	160

Steam is sometimes used with these machines, but owing to the difficulty of handling a hot machine and of getting rid of the exhaust, it should not be used except when air is not available.

Specifications

Ingersoll-Rand Tamping Machines

Symbol	"D-16"	"F-16"	"H-16"
Cylinder diameter, inches	3⅛	3½	5½
Stroke inches	12	12	20
Length with piston extended, without feed-screw and hanger, inches	60½	60½	100
Length with piston extended, with feed-screw and hanger, feet, inches	11′ 3¾	11′ 3¾	...
Travel of feed-screw, feet, inches	4′ 4″	4′ 4″	...
Diameter of supply pipe, standard pipe, in.	1″	1¼	1¼
* Size of shank, diameter and length, inches	1⅝x5½	1⅝x5½	1¾x6½
** Size of standard foot-piece or tamper, inches	12″x12″	12″x12″	12″x12″
Approximate Weights			
Machine without feed-screw and hanger, but with wrenches and fittings not boxed	330	375	945
Machine without feed-screw and hanger, but with wrenches and fittings, boxed	385	435	1160
Machine bare	325	370	925
Feed-screw with nuts, not boxed	95	95	...
Feed-screw with nuts, boxed	130	130	...
Hanger with bolts, not boxed	75	75	...
Hanger with bolts, boxed	110	110	...

Telegraph Names

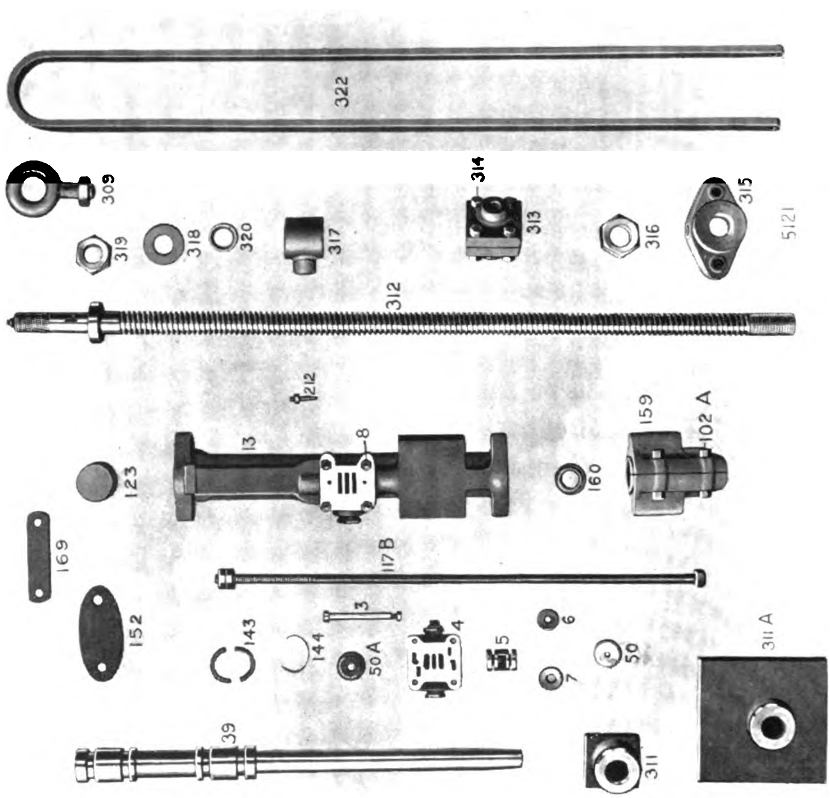
Machine with wrenches and fittings, but without feed-screw or hanger, "D-16" Legibilis; "F-16" Legibility; "H-16" Legibilium.

Machine with wrenches and fittings, with feed-screw but without hanger, "D-16" Legiferos; "F-16" Legionario.

Machine with wrenches and fittings, with feed-screw and hanger, "D-16" Legioned; "F-16" Legionense.

* Special U-bolt piston for separate tamping foot-piece furnished only on order.

** Other sizes of foot-piece will be furnished on order.



Duplicate Parts of Ingersoll-Rand Tamping Machines

Duplicate Part List
Ingersoll-Rand Tamping Machines

Sizes "D-16", "F-16", "H-16"

NUMBER AND NAME OF PART

Valve Chest and Valve Motion

4	Valve Chest (bare)
5	Valve
6	Valve Washer (2)
7	Valve Buffer (2)
3-A	Valve Guide Screw
3	Valve Guide and Nut
212	Valve Regulating Screw (2)
213	Valve Regulating Screw Key
214	Valve Regulating Plug and Nut (2)
50	Valve Chest Cover (2)
211	Valve Chest Cover Studs and Nuts (4)

Cylinder

13	Cylinder (bare)
8	Valve Chest Studs and Nuts (4)

Piston

39	Piston (tapered end)
143	Piston Rings (4)
144	Piston Ring Springs (4)
311	Tamping Foot (5″ square)
311-A	Tamping Foot (12″ square)
* 39-A	Piston (with solid foot)
* 39-B	Piston (with U-Bolt chuck)
*209	Chuck Key
*141	U-Bolt
*149	U-Bolt Nut
*140	Bushing

Steam Front Head

112	Front Head (2 piece)
102	Front Head Bolts and Nuts (2)
*111	Front Head Gland (2 piece)
*151	Gland Bolts and Nuts (2)
*117-A	Through Bolts and Nuts (2)

Air Front Head

159	Front Head (2 piece)
102-A	Front Head Bolts and Nuts (2)

Parts marked (*) not shown in cut.

NUMBER AND NAME OF PART

Air Front Head

160	Front Head Cup Leather
117-B	Through Bolts and Nuts (2)

Miscellaneous

123	Back Head
152	Cushion Spring (2 piece)
169	Cushion Spring Strap

Feed Attachment Mounting

312	Feed-Screw
313	Feed-Screw Nut (2 piece)
314	Feed-Screw Nut Bolts and Nuts (4)
315	Top Clamp
316	Top Clamp Nut
317	Swivel Joint
318	Feed-Screw Swivel Washer (2)
319	Swivel Jam Nut (2)
320	Swivel Cup Leather (2)
322	Hanger
*323	Hanger Bolts (2)
309	Hanger Eye Bolt and Nut
310	Hanger Eye Bolt Washer
*324	Set of piping for Attachment

Eye Bolt Mounting

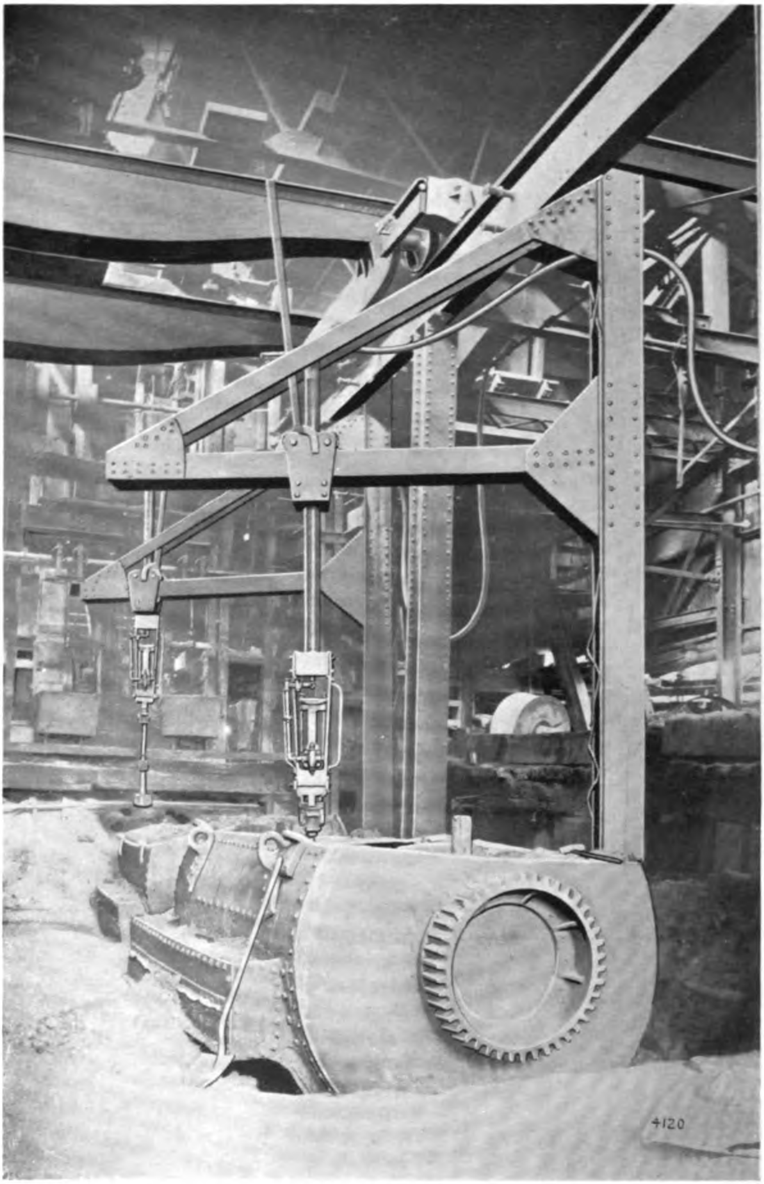
*309-A	Eye Bolt and Nut
*310	Eye Bolt Washer
*308	Eye Bolt Crosshead
*307	Crosshead Hanger Bolt and Nut (2)
*324-A	Set of piping for Attachment

Suspension Rod Mounting For "H-16" Only

* 13-A	Cylinder (bare with lugs)
* 8	Steam Chest Studs and Nuts
*306	Suspension Rod and Nut (2)
*305	Suspension Rod Gibs (2)
*304	Gib Set Screws (2)
*303	Gib Set Screw Jam Nuts (2)
*324-B	Set of piping for Attachment

Handles

*302	Guide Handle (2)
*301	Guide Handle Tap Bolts (8)



Tamping Converter Linings at the United Verde Copper Mining Co's. Plant, Jerome, Ariz.

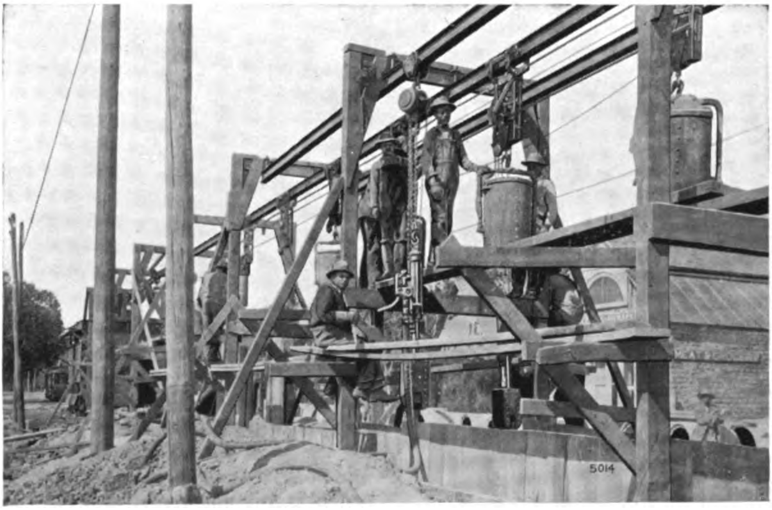
The MASON-HENRY Press
Syracuse and New York

SHEET PILE DRIVER

INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Form No. 9009 September, 1910

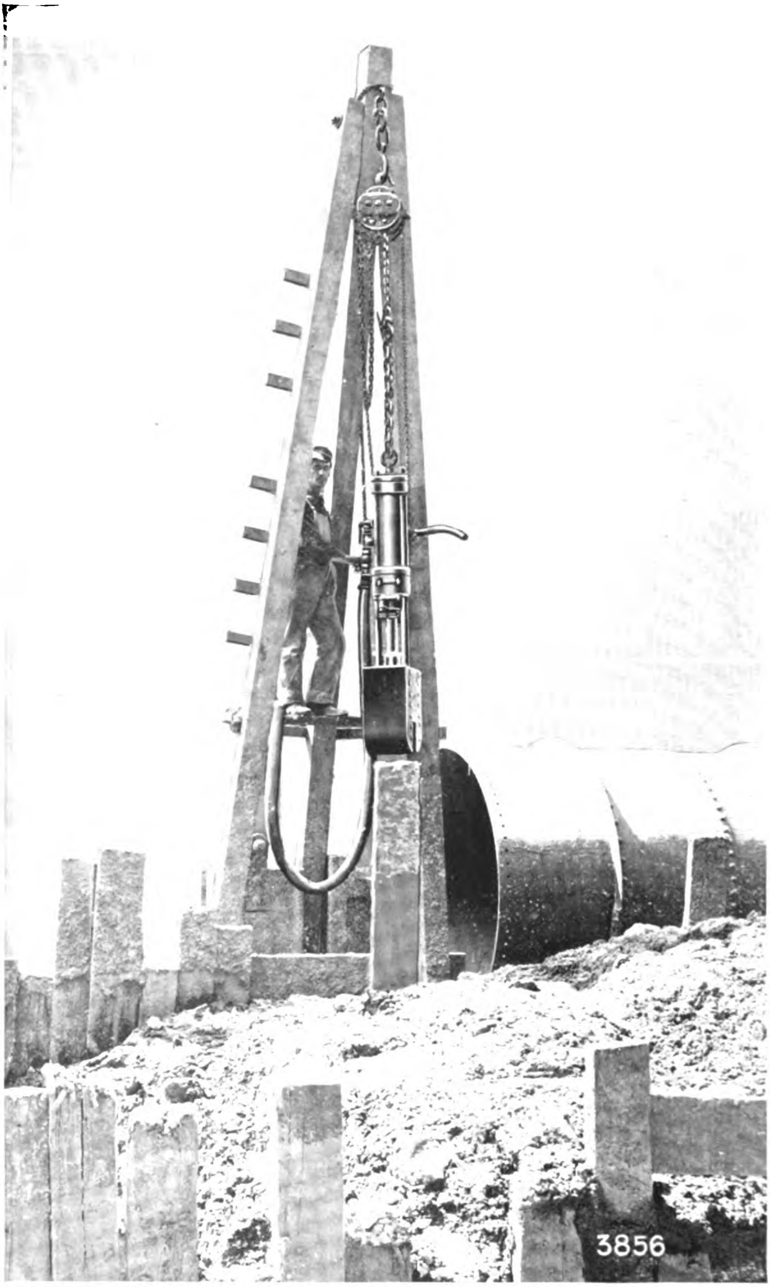


Two Ingersoll-Rand Pile Drivers at Work on a Sewer System at Albuquerque

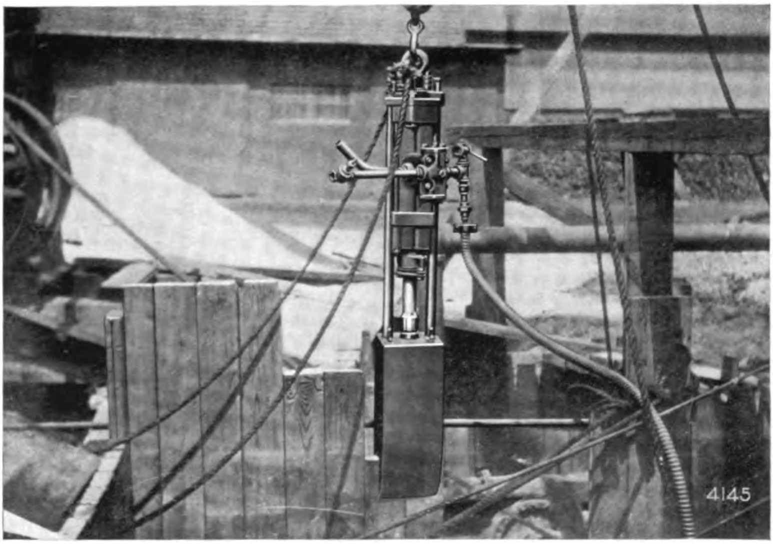
THE use of sheet piling, whether of wood or steel, is growing more general every year in mine, contract and construction work, and increasing attention is being given to economical methods of driving it rapidly and without injury.

In trench excavation for sewers, water mains, or conduits, where any depth must be reached in a material with a tendency to cave or where water is encountered, sheet piling is essential. In sinking cofferdams, especially where mud or quicksand is involved, success depends upon the proper use of sheet piling. Such cases may occur in sinking foundations; in building bridge piers or abutments; in carrying railway or roadway embankments over marshy ground; in making dock or wharf improvements along the water front.

In sinking shafts for mine or contract through a soft material, sheet piling may be driven down as the work progresses, acting instead of a caisson. In making a tunnel approach it keeps out the soft materials



Ingersoll-Rand Sheet Pile Driver on Sewer Excavation Work, Jersey City, N. J.



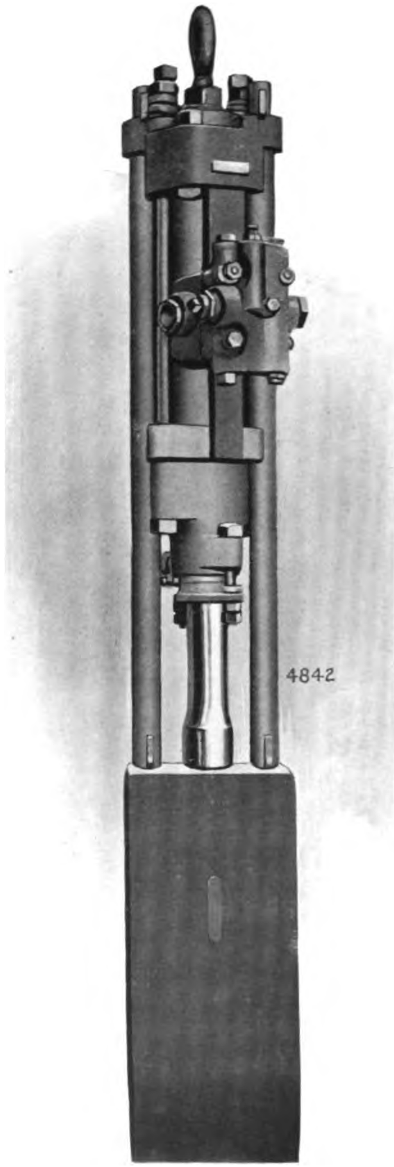
Ingersoll-Rand Sheet Pile Driver on Excavation Work, Pawtucket, R. I.

from the cut until a more permanent wall can be built. In building retaining walls, sheet piling may be used either as the permanent structure or merely as a preliminary to a masonry or concrete wall. Practically the same purpose may be served where it is necessary to build a foundation or footing for a new structure close to the wall of an existing building.

In canal work for irrigation or navigation, sheet piling may be required to retain the walls where the cut passes through material which would otherwise wash, or run down into the channel. For dam construction sheet piling may serve as the basis for a low dam of other materials; or, where a dam is to be carried across a valley, it may serve as a cut-off under the dam or beneath a core wall. It may also be used as a permanent enclosing wall for the masonry or concrete structure of a dam or other foundation carried down to an impervious stratum.

The Requirements of Successful Pile Driving

In such work as just described, certain factors are essential to the successful carrying on of the enterprise. First, the pile must be driven with as little injury, and as steadily and uniformly as possible, making tight joints for the exclusion of earth, sand or water. Where several courses of piling are necessary, or where spliced piles must be used, the method



Standard Ingersoll-Rand "G-1" Sheet Pile Driver

of driving must be such that the upper pile is not forced aside from the lower. Finally, the method of driving must be such as to return the highest economy in time, labor, power and repairs.

Heavy Pile Drivers

Where a heavy hammer with a very powerful blow is used on sheet piling, only a portion of the energy is expended in actual penetration. The rest of it is consumed in the spring and vibration of the pile. This is true whether the pile driver used be of the heavy steam hammer type or of the drop type. One result of this method of driving is a frequent buckling of the pile, cramping and loss of alignment under the severe side strain of the heavy hammer. Broken wood piles and bent steel piling are too often the accompaniment of the heavy pile driver. Another objection to the heavy hammer is the rapid "brooming" of the top of the pile. In practise it is found necessary to interpose a wooden block between the pile and the hammer, which must be repeatedly renewed under the terrific blow of the heavy machine.

The Light Pile Driver

A system of drive using many rapid, sharp, but comparatively light blows has been found by experience to avoid these troubles. There is not so much springing or vibration of the pile and the rapid succession of impulses is applied almost entirely in penetration. There is no likelihood of the buckling, binding or breaking of the pile, with loss of alignment, an imperfect joint and the frequent necessity of removing an injured pile. "Brooming" of the top is avoided by the use of an anvil block of metal which rests close on the pile and receives the blow of the hammer. There are in addition other advantages to be credited to the lighter machine of the Ingersoll-Rand type.

Any mechanical pile driver requires a hoisting gear for suspension, moving and operation. Steam pile drivers and drop pile drivers must work in guides and the whole rig must be moved in line with each pile. The light pile driver, on the contrary, suspended by a line from a derrick, or otherwise, needs no guides and is easily swung from one pile to the next with a great saving of time. The light machine requires a much smaller engine and boiler for handling it, meaning the saving of fuel and power. It permits the use of a much lighter derrick at lower first cost. The combination of a light machine and a light derrick means better time

made and greater ease of handling in covering a given job. Where guides for the piles are necessary they can be put in place without regard to the lighter machine and, because there is less buckling tendency, they need not be so long or so strong.

Hand Driving

The comparison thus far has simply been between two different methods of driving sheet piling by machine. It seems hardly necessary to make a comparison between machine driving and hand driving. As a matter of fact, almost any machine method is so far ahead of hand methods that the latter should hardly be considered on a job of any magnitude.

In hard ground it is simply impossible to drive sheet piles by hand. In any ground, it is slow costly work, and no such depths can be reached by hand driving as by machine driving. The question confronting the contractor seeking the best results, most rapid progress and lowest cost, is no longer whether he shall use a machine pile driver, but rather which machine shall he adopt.

The Ingersoll-Rand Sheet Pile Driver is the pioneer of these lighter types and stands upon its merits today as the most practical and economical means of driving sheet piling, for whatever purpose.

It is a development of one of the standard types of Ingersoll-Rand Rock Drills and is built in the same shops and by the same men and methods as the drills themselves. It therefore embodies all the superiorities of design, material and workmanship which have won a place for Ingersoll-Rand rock drills as standards of power and economy. The machine may be operated either by steam or compressed air, thus adapting it to any contract equipment.

Construction Details

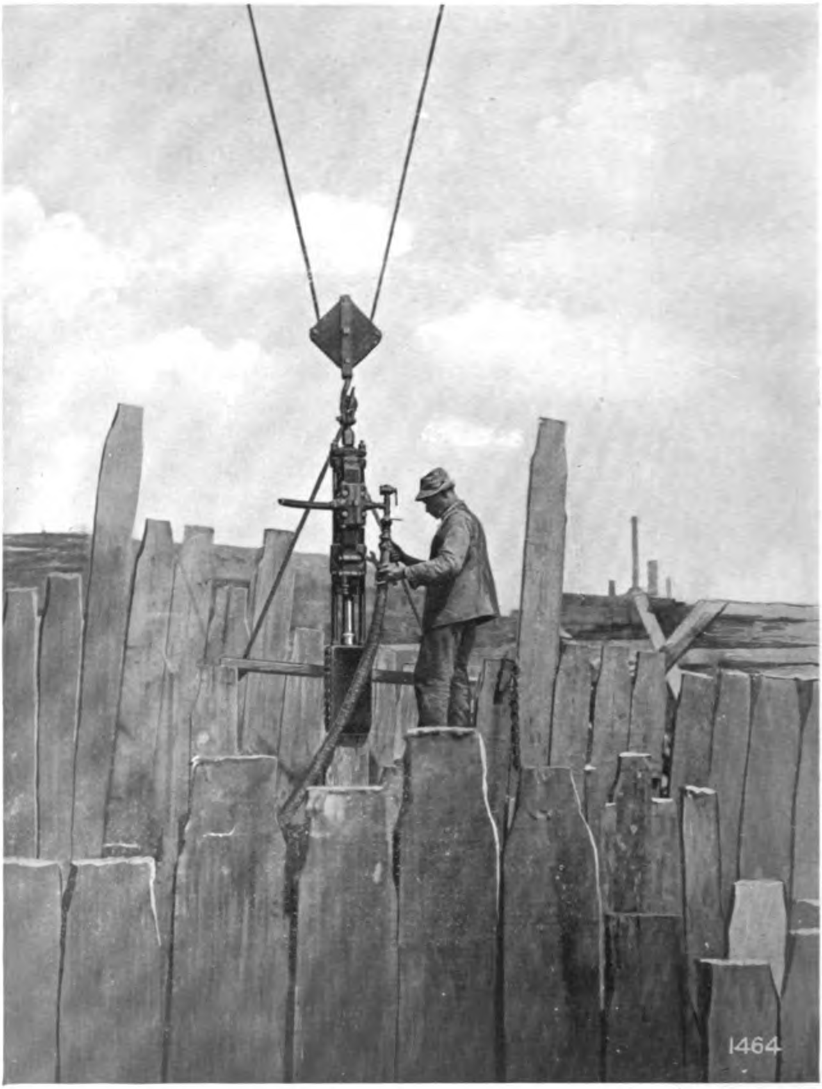
This machine has a cylinder diameter of four inches and a stroke of from seven to eight inches. Its hammer is similar to the ordinary rock drill piston, except that the chuck of the latter is replaced by a flat striking or hammer end. The adjustments are such that the piston cannot strike the front head of the cylinder when the anvil block is on the pile; and an arrangement on the valve chest maintains a suitable clearance protecting the back head on the up stroke. The character of the work and the fact that there is very little variation of stroke, makes possible the use of very small clearance. The machine is thus economical of air or steam.

The piston or hammer has only its own weight to lift, so that the lower or lifting piston area can be much smaller than in the rock drill. This not only uses less air on the up stroke, but also gives a much heavier and stronger piston or hammer rod.

Large steel tie rods running from the back head of the cylinder support a heavy cast iron foot-piece with a slot which fits over the head of the pile. Within this foot-piece is a steel anvil block of T-shape. The bar of the "T" rests on the top of the pile and the upright passes upward through the foot-piece in line with the hammer. The anvil block is slotted and held in the foot-piece by a steel key which permits a vertical play of about one inch but which prevents the block from falling out entirely. This steel key is never exposed to the hammer blow, except through the carelessness or neglect of the operator.

Ingersoll-Rand Sheet Pile Driver at Boston Navy Yard

The valve action is entirely automatic and movement begins the instant the throttle is open. No manipulation or variation of the stroke is required, as the machine always strikes its full swinging blow. There are no delicate parts to get out of order, and about all the attention required is an adequate supply of oil which is furnished through the oiler on the supply pipe. None of the working parts are exposed and the machine will stand almost any kind of neglect and more than a reasonable amount of abuse. A heavy eye-bolt in the back head provides for a suitable suspension. The through bolts holding the front and back heads to the cylinder are entirely independent of the tie rods supporting the foot-piece. The total weight of the machine is about 1200 pounds, most of this being in the heavy foot-piece. The object of concentrating the weight at this point is to absorb the reaction of the pile driver in operation and to prevent its recoil from the pile head. The foot-piece has holes



Ingersoll-Rand Sheet Pile Driver, Showing a Common Methcd of Suspension

for the insertion of a bar to guide the piles in starting. The jaw or slot in the foot-piece is about 11 inches long and from 3¼ to 4¼ inches wide as ordered. The machine is suitable for sheet piles 12 inches by 3 to 4 inches in section up to 25 feet in length. But 2-inch sheeting has been driven without injury with this device.

The Method of Suspension

When in operation the full weight of the machine should rest on the pile. But a suitable rigging must be provided for moving the pile driver from place to place; and the amount of work which the machine will do depends very largely upon the convenience of the rigging and the rapidity with which it may be moved. Several methods of suspension may be used.

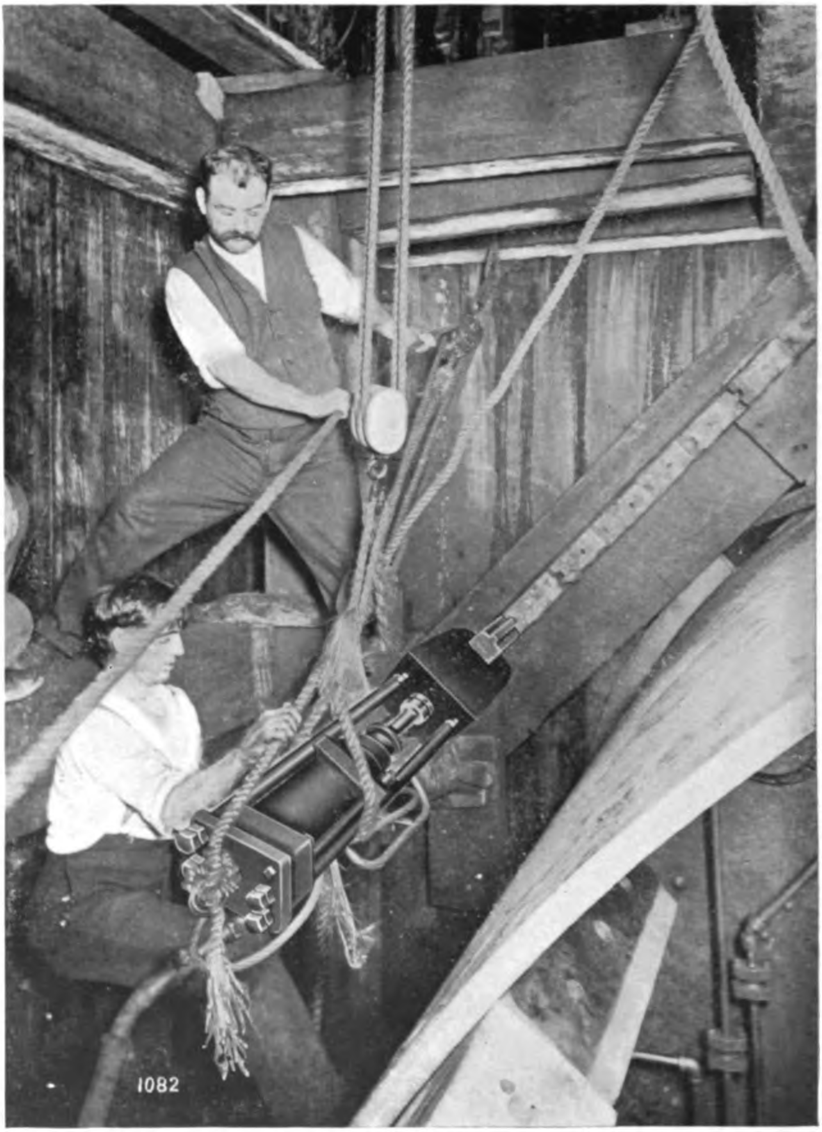
In caisson, shaft, abutment, foundation or other work within a limited area, the best way of handling the pile driver is to swing it from a derrick boom, the derrick being so placed as to permit covering the whole work without moving the mast. This method may also be used for driving a long line of piling, in which case the length of work covered by one setting of the derrick is approximately twice the length of the swinging boom. This, however, calls for frequent moving of the derrick and is not as convenient as the next method to be described.

Where long lines of piling are to be driven, as in water front improvements, dam construction or trenching, two towers may be built on the line of piling located as far apart as circumstances permit. Between these towers a steel cable is stretched, carrying a moving trolley from which the pile driver is suspended by block and tackle.

The third arrangement consists of a tripod rigging or similar frame, mounted on wheels and moved bodily along the line of work on a rough track. The pile driver swings from the center of the frame above the line of piles to be driven.

Where piles are to be driven vertically the machine is simply hung by its eye-bolt from the back head. In cases where piles are to be driven horizontally or at an angle, a sling or double suspension must be used, hung from a block and tackle at the required angle.

It is the comparatively light weight of the Ingersoll-Rand Sheet Pile Driver which gives it a tremendous advantage in all classes of service for covering work over an extended area. A rubber hose from the steam or air line gives the necessary flexibility of supply.



Ingersoll-Rand Sheet Pile Driver Working Horizontally in Close Quarters in a Tunnel

Method of Operation

With the pile in place ready for starting, the pile driver is lowered until the jaw of the foot-piece covers the top of the pile and the anvil block rests on the pile end, which has been previously squared up. The block and tackle supporting the machine are eased off until the entire weight is on the pile; but the driver must be held in line with the pile. The throttle is then opened partially, starting with light blows and increasing their force by opening the throttle as the pile gets under way. When penetration has fairly begun the throttle is opened wide and the machine run at full power.

The hammer end of the piston strikes the top end of the anvil block and the full force of the blow is communicated to the pile. The recoil is absorbed by the heavy foot-piece and the anvil block never leaves the end of the pile. As the pile descends, the tackle is eased off so that the weight always rests on the pile. The blows come so rapidly that there is no time for the pile to react and every ounce of the energy applied is expended in penetration. A peculiar effect of this succession of light, rapid blows combined with the steady weight of the machine on the end of the pile, is that the latter seems to be pushed rather than driven into the ground.

As stated, the block and tackle is released, as the pile sinks, just enough so that the full weight of the machine is always on the anvil block and pile. There is no side motion, no swaying, no tendency to get out of line. So long as the machine is properly fed downward with the sinking of the pile, there is no possibility of the piston striking the front head with injury to the machine. Nor can the blow on the anvil block come upon the guide key in the foot-piece. Trouble at these two points can arise only from a wilful neglect of ordinary precautions.

Used with Wood Piling

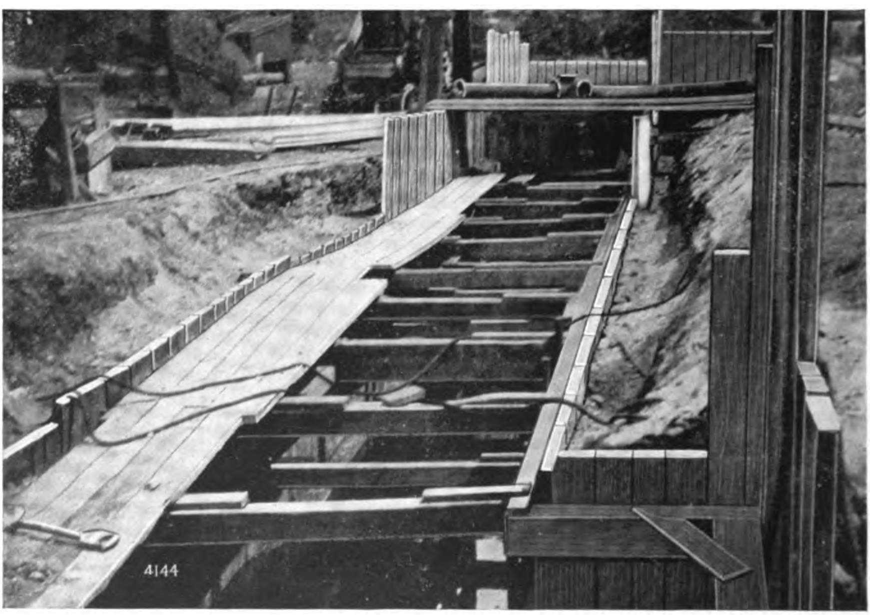
Experience has shown that there is no appreciable "brooming" of the pile head with the Ingersoll-Rand Sheet Pile Driver, nor does it split the plank if the latter has been properly squared at the outset. This is because the anvil block always rests full and flat on the pile end. Troublesome delays are thus avoided while the injured top of a pile is cut off and waste of the pile length is also eliminated. A very important consideration is to have the pile driver properly in line with the pile. This is an absolute protection against split or sprung piles, and assures correct alignment and good, close joints.

Used with Steel Piling

A loose steel head fitting any shape or system of steel sheet piling can be provided, with an oak or hard wood block between head and anvil block, the head slipping over the pile and the wood block fitting the anvil block of the pile driver. When so equipped this machine drives steel piling with the least possible injury and waste. The steady advance under the rapid blows and the freedom from vibration, side strain and buckling, give results with steel piling which cannot be secured with any other type of machine driver.

Using the Water Jet

In some sands and gravels it is impossible to drive sheet piling by any method without the use of a water jet directed at the point of the pile. This can be supplied by a pump run from the same source as the pile driver. But in all ordinary materials piling can be driven simply with the machine driver alone. without other assistance.



Trench Showing Piling Driven by Ingersoll-Rand Sheet Pile Driver

Capacity

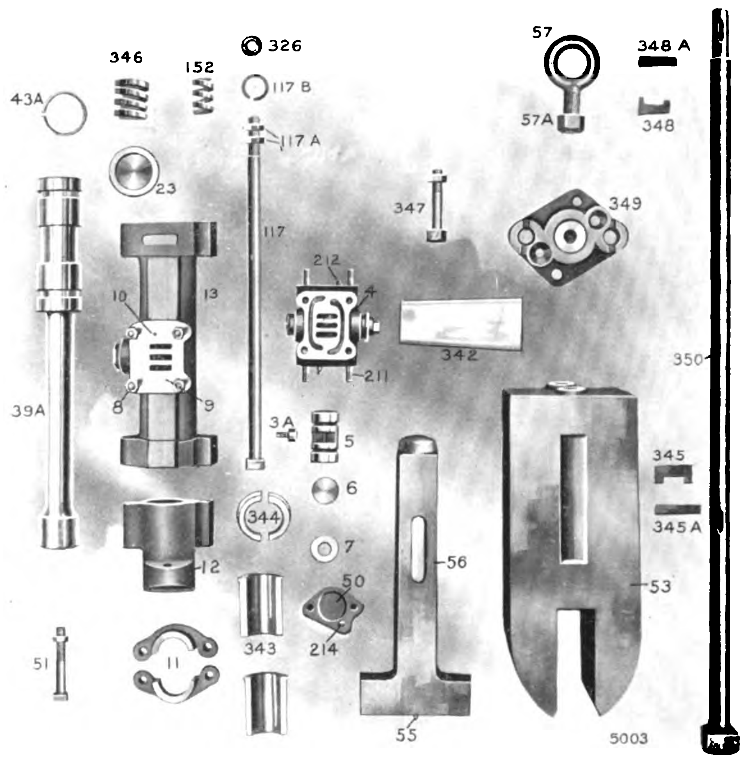
It is impossible to give exact figures as to the capacity of the Ingersoll-Rand Pile Driver since so many uncertain factors enter into the problem and no two cases offer the same conditions. The penetration will of course vary in different materials and under varying pressures on the machine piston. The total footage of piling driven per day will depend not only upon the factors already mentioned, but also upon the handiness of the rig for handling the machine and upon the skill of the men operating it.

In general, however, it may be stated that one of these machines will do the work of from 15 to 20 men using hand mauls, and will require the attention of only two men. There is really more to the question than this indicates, for the Ingersoll-Rand Sheet Pile Driver successfully drives piles of a length and to a depth which no number of hand mauls can attain. In one case two 8-inch by 3-inch planks were driven together as a single pile through hard gravel at a rate of one foot in 45 seconds. In another case 60 to 80 interlocking steel piles 3¼ inches by 16 inches and 8 feet long were driven per eight hour shift.

Descriptive Table of Ingersoll-Rand "G-1" Sheet Pile Driver

DIMENSIONS:		Telegraph Name—LEECHES
Diameter of Cylinder	in.	4
Length of Stroke	in.	7¼
Length over all	in.	80
Clearance required (distance from center line to back)	in.	3¾
Anvil Block	in.	11 x 11¼ x 27
*Jaw (for 3-inch Piles)	in.	3¼ x 11¼ (9 in. deep)
Diameter of Supply Pipe	in.	1¼
Size of Steam or Air Line (50 to 300 ft.)	in.	1½
Approximate Strokes per Minute		300
Boiler H. P. required when driven with steam		7 to 12
Cubic Feet free air per minute (75 to 90 lbs. pressure)		90 to 130
APPROXIMATE WEIGHTS:		
Pile Driver Complete with Fittings, Boxed	lbs.	1375
Pile Driver Complete without Fittings, not Boxed	lbs.	1200

*Special foot-piece with 4¼-inch jaw can be furnished on order.
Fittings include throttle, oiler and wrenches.



Duplicate Parts of "G-1" Sheet Pile Driver

Duplicate Part List, Size "G-1"

Part No.	
	Valve Chest Complete
5	Valve
3A	Valve Guide Screw
4	Valve Chest, Bare (Includes Chest Cover Studs and Nuts)
6	Valve Washer (2)
7	Valve Buffer (2)
50	Valve Chest Cover (2)
211	Valve Chest Cover Stud and Nut (4)
212	Valve Regulating Screw (2)
*213	Valve Regulating Screw Key
214	Valve Regulating Screw Plug (2)
13	Cylinder Bare or Complete (Includes Valve Chest Studs and Exhaust Port Bushings)
8	Valve Chest Stud and Nut (4)
9	Exhaust Port Bushing (Front)
10	Exhaust Port Bushing (Back)
	Steam Front Head Complete
12	Front Head Bare
343	Front Head Split Bushing (2 pieces)
344	Front Head Split Ring (2 pieces)
11	Front Head Split Gland (2 pieces)
51	Front Head Split Gland Bolt and Nut (2)
	Anvil Block Complete
53	Anvil Block Bare
56	Anvil Plug Bare (Includes Anvil Dowel Pin)
55	Anvil Plug Dowel Pin
342	Anvil Plug Key
	†Piston Complete (with 2 Segment Rings)
*39	Piston Bare (for 2 Segment Rings)
*43	Piston Ring (2 Segment) (2)
*44	Piston Ring Spring
	Piston Complete (with Snap Piston Rings) (2)
39A	Piston Bare
43A	Piston Rings (Snap) (2)
	Miscellaneous Parts
23	Back Head
346	Back Head Spring
349	Back Head Clamp
347	Back Head Clamp Bolt and Nut (2)
117	Through Bolt and Nuts (2)
326	Through Bolt Washer (2)
152	Cushion Spring (2)
350	Side Rod (2)
345	Side Rod Gib (2 in.) (2)
345A	Side Rod Gib Key (for 2 in. Gib) (2)
348	Side Rod Gib (1¾ in.) (2)
348A	Side Rod Gib Key (for 1¾ in. Gib) (2)
57	Eye Bolt (1½ in.)
57A	Eye Bolt Nut (1½ in.)

Note: Parts marked (*) are not shown on cut.

†Pistons using 2 segement rings are old style.

FORM 74

FEBRUARY 1910

WATER LIFTED

BY

COMPRESSED AIR

FOR

MUNICIPAL, MANUFACTURING, IRRIGATION, OR OTHER WATER SUPPLY

INGERSOLL-RAND COMPANY
11 BROADWAY
NEW YORK

11 BROADWAY, NEW YORK, U. S. A.

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CLEVELAND, OHIO, Williamson Building

DENVER, COL., 1718 California Street

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TORONTO, ONTARIO, 1105 Traders' Bank Building

VALPARAISO, CHILE, Calle Blanco

VANCOUVER, B. C., 449 Pender Street

WINNIPEG, MANITOBA, 406 Travellers Building

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"Outsider, Johannesburg"

Codes Used

Ingersoll-Rand, Liebers, A1, Western Union, A B C (4th and 5th Editions)
Foreign Offices use Bentley's Code also.

THE "AIR LIFT" SYSTEM

During recent years much progress has been made in the art of pumping water by compressed air. The Ingersoll-Rand Company has done pioneer work in this line since the introduction of the "Pohlé Air Lift" in 1892, being the first to employ Dr. Julius G. Pohlé, who is acknowledged to be the original inventor of the "Air Lift." Later the Company acquired all right, title and interest in the Pohlé Air Lift patents. At first all systems for lifting water or liquids by compressed air were admitted to be extravagent, but with a large experience now behind us, and with marked improvements in air compressor economy, the Air Lift has made valuable strides. We have found that a properly installed Air Lift System requires the attention of the engineer, who should, in the first place, specify a suitable compressor provided with automatic attachments, and he should design the air and water pipes to accomplish the best results. Each case should be treated by itself, and advice given in accordance with the conditions that exist in each well to be pumped. We have an experienced corps of engineers, and are prepared to furnish specifications and advice free of charge.

Discharge of an Air Lift Pumping Plant.

WATER SUPPLY FOR PUBLIC USE

With the decrease in surface water supply, due to cutting down the forests and meteorological changes, the population has increased enormously, cities have grown together, the country population has become more dense, and the danger of pollution of surface streams of water has increased a hundred-fold. As the years go on, and population and industries multiply, the question will become a more and more important one.

Filtered Water Expensive

Filtration has not proved as successful as some of its enthusiastic promoters had hoped. Such plants usually cost many times over the expense of a good artesian supply. In one of the finest interior cities, using about twenty million gallons, it was found that, everything figured in, filtered water delivered to the user actually costs four to five times as much as would an Air Lift supply.

Artesian or Well Supply

Many of our interior sections must depend upon well water, and there are few districts where an ample supply is not to be secured from wells properly made. This water is generally pure and wholesome. It is also of uniform temperature the year round—cool and pleasant in the summer, because the underground pipe and soil temperature remain uniformly low. In winter, well water, being warmer than that taken from lakes and rivers, is not so apt to freeze, and, from all considerations of temperature and purity, well water is greatly to be preferred. Many cities located on rivers having a gravel bed formation find that, by placing wells of suitable construction far enough back from the bank, there is a natural filter bed, leaving the water perfectly clear, even when the river itself is chronically muddy. When river or other surface water is good the wells may be drilled close to the edge, the water flowing down from the top of the wells.

Even when the supply near the surface is either scanty or unsafe, it is usually possible to sink driven wells to greater depths, thus "casing off" all suspected water and drawing only from deeper rock or gravel veins removed from all danger of surface contamination. The natural head from lower veins often maintains the water near the surface so that power only need be expended for moderate lifts.

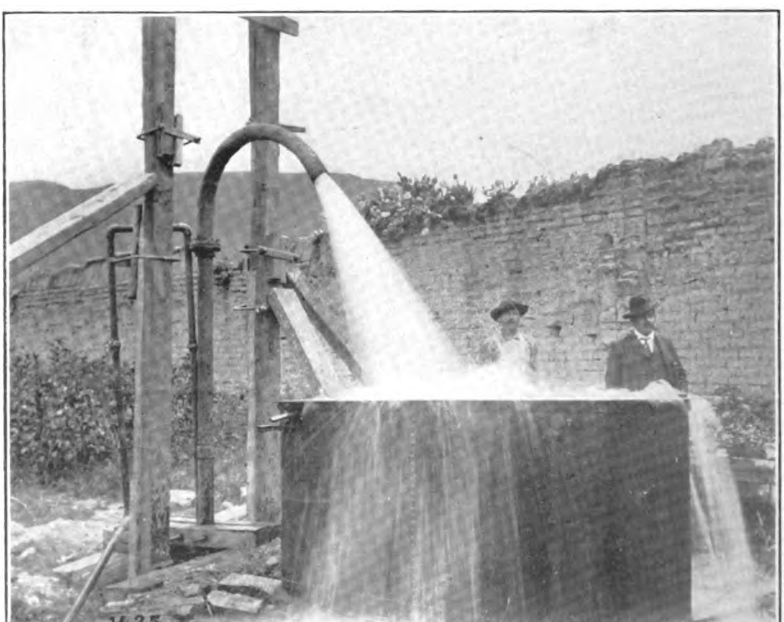
There are not many underground formations where wells should be located close together. Such wells may affect or rob each other, and it is usually best to spread them out on a line across what is known to be the underground flow. Some finely creviced or tight rock formations have a strong head with but little capacity, and wells in such formations, if pumped hard, yield but little additional water. They

should be scattered and pumped moderately, maintaining a low and economical lift. In other cases, one well in a group will give as much water as all together, and more territory must be drawn on. This introduces difficulties in detached pumping units and labor cost, which are well met with the Air Lift, as an economical central air compressor can be put in at the main pumping station and operated by the usual engineering force and the air piped to any distance or in different directions, and to **any number of wells, no matter how scattered.** In this way the entire corporation area is available for a supply. Air transmission is safe and clean; it is simple and easily controlled. There is little or no wear, and, once adjusted, the wells need no attention for years, the control resting in the speed maintained at the central station.

Uses for the Air Lift

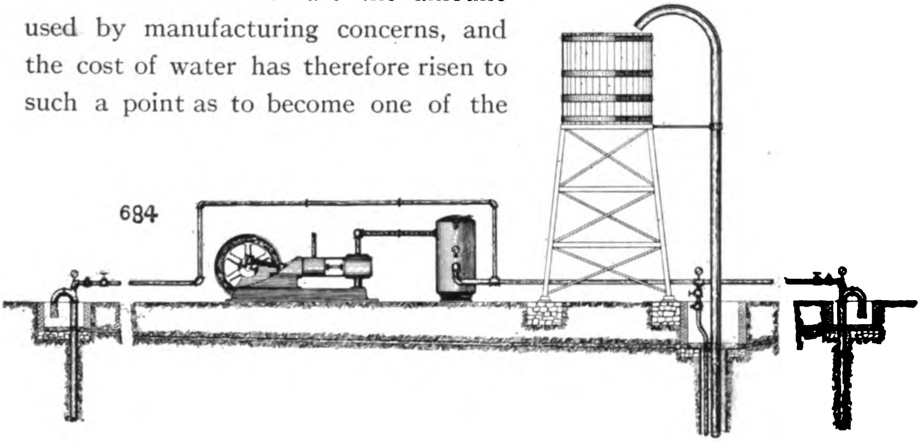
City and town water works, asylums and hospitals, plantations, railway water tanks, irrigation, private country houses, pumping mines, ice manufactories, breweries, cold storage and packing houses, textile mills, dye works, bleacheries, sewerage installations, dry docks, seaside water works, stock farms, etc.

In fact, anywhere and everywhere that clear and abundant water is needed.



Air Lift Plant at Toluca, Mexico.

In many cases private water companies and cities have installed water meters to measure the amount used by manufacturing concerns, and the cost of water has therefore risen to such a point as to become one of the



Pohlé Air Lift, Operated by a Steam-Driven Straight-Line Air Compressor.

considerable expenses to any manufacturing plant. The insurance companies have also placed restrictions on such establishments and have made demands which make it desirable to have an independent water supply.

At the present time, after an extensive experience, two general systems have been devised for this purpose. One, known as the Deep Well Pump System, for which a working pump is used, and the other the Air Lift System, which employs compressed air to raise the water, by means of its inherent expansive force and the difference in specific gravity between compressed air and water.

The Equipment Required

The Air Lift involves the use of an air compressor, located where the expense of attendance is least; an air receiver adjacent to this compressor; a pipe line for conveying the air from the receiver to the wells; one or more wells drilled to a depth proportionate to the height of the lift and the depth of the water strata below the surface; air and water pipes running down inside of these wells, the proper proportion of their vertical length being submerged when at work, representing the pumping apparatus proper.

THEORY OF THE AIR LIFT

Opinions differ as to the true theory of the Air Lift. A common Air Lift case is one where we have a driven well in which the water has risen approximately near the surface. We place in this well a large pipe for the discharge of the water. This is known as an "eduction pipe." This pipe does not touch the bottom of the well, but is elevated above it so as to freely admit the water through its lower open end. Alongside of this pipe, either on the outside or within, is a small pipe properly proportioned and intended to convey compressed air to a point near the bottom of the eduction pipe. It is usual to provide what is called a "foot-piece," which forms the nozzle connecting the air pipe with the water pipe, but in what is known as the "central pipe system" this foot-piece is not used, the air pipe being placed within the eduction pipe to a point near the bottom, where it discharges the compressed air into the water column.

The air pipe is connected with an air receiver on the surface, which is in or near the engine room, in which there is an air compressor. This air pipe is provided with a valve on the surface. Before turning on the air the conditions in the well show water at the same level on the outside and inside of the eduction pipe. At the first operation we must have sufficient air pressure to discharge the column of water which stands in the eduction pipe. This goes out *en masse*, after which the pump assumes a normal condition, the air pressure being lowered and standing at such a point as corresponds with the normal conditions in the well. This is determined by the volume of water which the well will yield in a certain time and the elevation to which the water is discharged. Here comes in the value of experience in laying out the pipes, which should be proportioned to meet normal conditions.

The Frizell System or Lifting by Bubbles

It was at first supposed that in all air lift cases the water was discharged because of the aeration of the water in the eduction pipe, due to the intimate commingling of air and water. Bubbles of air rising in a water column not only have a tendency to carry particles of water with the air, but the column is made lighter, and, with a submergence or weight of water on the outside of the eduction pipe, there would naturally be a constant discharge of air and water. This is known as the Frizell System, and where the lifts are moderate—that is, where the

water in the well reaches a point near the surface—it is very likely that the discharge is due to simple aeration.

Piston-Like Layers

Most air lift propositions are deep well cases—that is, the water is lifted a distance greater than 25 feet; and just in proportion as the lift is increased do we get away from the aerated form idea and reach the Pohlé System of piston-like layers. To understand the distinction and the importance of proper pipe proportions let us take an exaggerated case, where we have a lift of, say, 100 feet and a diameter of eduction pipe of 12 feet. Such a case as this is impracticable, and no matter how much air is discharged into this pipe it is likely to rise in the shape of bubbles, some of them larger than others, because as they ascend they cohere; but piston-like layers can only be formed in so large a pipe as this under conditions where there is a sufficient head or height of discharge and an enormous volume of water. In other words, the volume of water admitted to this pipe of large diameter must be sufficient to keep pace with the large volume of air admitted.

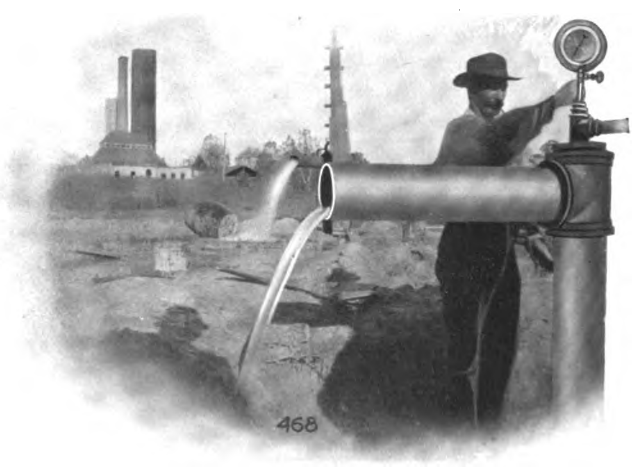
The economy of the Air Lift System is in direct proportion to the capacity of the well to form piston-like layers, and the reason why these layers are formed is that after the first discharge there is kept up a constant struggle between the air under pressure and the head of water on the outside of the pipe, each one seeking to enter the lower end of the eduction pipe. When the air pressure is greater than the head of water a certain volume of compressed air is admitted into the eduction pipe. The water in this pipe is at that time moving rapidly upward; that is, its momentum has been established. Hence the air takes up this velocity and goes upward with the water. If a sufficient quantity of air has been admitted in proportion to the diameter of the pipe, and if there is a sufficient pressure in this pipe to prevent the free discharge of the air, we can see how readily this bubble of air spreads itself across the diameter of the pipe in a piston-like condition. The reason why this air piston is not elongated and continuous is that the free discharge of the air, aided by the velocity with which everything in the eduction pipe is moving, causes a fall in the air pressure just sufficient to allow the head of water to press the water into the air space from the open end of the eduction pipe. In other words, as the air pressure is slightly lowered, the water pressure, which was nearly equal to the air pressure, becomes a little greater and a piston-like layer of water enters the pipe, shutting off the air. This "chunk" of water rises in the eduction pipe with velocity equal to that of the air, and, as it has plugged off the air nozzle, there is a momentary rest, during which the air has a chance to accumulate greater pressure, and just as soon as its pressure over-

comes that of the water the conditions are reversed and another "chunk" of compressed air is discharged into the pipe, shutting off the water for an instant. This process is continuous and as regular as the movement of a pendulum.

As these "chunks" of air approach the surface they are gradually enlarged, because of the reduced load upon them, and it is likely that before they reach the surface there is a general breaking up of the piston-like layer conditions; but it is important that each plant should be installed with the idea of maintaining the piston-like layers as far as may be possible.

Yield of Well Increased

One of the reasons for the success of the Air Lift System is that it increases the yield of the well from two to seven times and we can cite many instances where this has been demonstrated. This is well illustrated by a comparison of the two pictures of the wells at the water works, Houston, Texas, as shown on this and the opposite pages. They show some of the thirty wells operated by one compressor. The power-house and standpipes are shown nearly half a mile beyond. In a test made at the Bethlehem, Pa., Water Works, one 8-inch well flowing 180



Wells at the Houston (Texas) Water Works, Showing the Flow Before the Application of Compressed Air.

gallons of water per minute, was made to yield 1,263 gallons by the Air Lift System. As much as 900 gallons of water per minute have been forced from a single 6-inch well, but this is an extreme case with a remarkably strong well, and the economical rate is much lower—say, up to 300 gallons per minute from a 6-inch, up to 600 gallons from an 8-inch well. The Air Lift will handle all the water a well can yield, but if a certain 8-inch well is equal to a flow of only 100 gallons, the Air Lift, of course, cannot pump more. Its large capacity comes from the fact that there is little in the well to interfere with the flow of a continuous stream the full size of the bore hole, if that quantity will come into the well. There are no moving, finished or working parts underground—

Wells at the Houston (Texas) Water Works, Showing Flow After the Application of Compressed Air.

simply two pipes which, when adjusted, need not be seen for years; the single machine being in the compressor room, subject to the same working conditions as a steam engine, lasting as long and requiring no more attention. None of the working parts of the compressor come in contact with the water, and they may, therefore, be properly lubricated, wearing indefinitely.

In one of the earliest city plants where the water source was fine sand and the original yield was 70 gallons per minute it is now 170 gallons, due solely to the application of the Air Lift pump. Several other wells were improved proportionately. Nearly all wells, whether driven in sand, gravel or rock, **increase steadily with use,** the steady, even flow toward the wells cleaning out and enlarging the water-carrying channels and crevices, causing the well to draw from a larger area.

Water Is Cooled

In breweries, ice factories and for condensing purposes it is, of course, important that the water pumped be as cold as possible, and many have adopted the Air Lift because they find that water pumped in this way is from 2 to 3 degrees colder than in the well, and from 10 to 40 degrees colder than surface water. This is due to the expansion of air, which abstracts the heat from the water, with which it is in close contact.

Water Is Purified

A feature of the Air Lift, entirely outside all considerations of comparative cost, is that its use improves or purifies the water pumped. Prof. Drown, of Lehigh University, says: "The success of filtration is largely dependent upon aeration." With naturally filtered rock or sand water, entirely shut off from surface pollution and pumped by the Air Lift, ideal conditions are reached. There is a most complete aeration or mixture under pressure, and as the water flows upward mixed with the air it separates and throws off most of the sulphur gas, precipitates much of the iron, retards or prevents the growth of vegetable matter, germs or organisms, and results in clear and palatable water. Air Lift water remains clear and sparkling after long exposure.

Well water which had been condemned by Boards of Health has been approved and praised highly by the same Board later when pumped from the same wells with air.

There are some wells unfit for manufacturing use because so strongly impregnated with sulphur, iron and acids. With the Air Lift these wells become available, and the air as it leaves the discharging water has a pronounced odor, but the aerated water analyzes 90 per cent. less impurities. There are some elements on which the air has no influence, but the general effect is to improve.

As an instance, to show the value of aeration, we may cite the case of the Asbury Park, N. J., Water Works. This water is very strongly impregnated with iron, and when pumped by a steam piston pump was practically unfit for domestic use. By the use of the Air Lift, however, 2,500,000 gallons as clear and wholesome as spring water are daily delivered into the standpipe.

Compressors May Be Any Reasonable Distance from the Well

As compressed air can be conducted for miles with little loss, the compressor may be placed in the engine room directly under the care of the present engineer and the air conveyed in uncovered pipes to the wells, which may be any reasonable distance away.

Air Lift Plant at City Water Works, Corsicana, Texas. Pumps from Wells about Two Miles Apart.

Any Number of Wells Can Be Pumped

Where large quantities of water are required it is usually necessary to pump from a number of wells, and by the Air Lift System this can be done with only one compressor. The wells themselves require no attention, as they are regulated by the flow of air, and it makes no difference how many wells are on the same line, how they are scattered or how far away, the principle is the same, and it is simply a question of properly arranged pipe line and valves for each well. Where good water is not at hand an air line can usually bring it some distance cheaper and better than by other means. The necessity of maintaining a number of separate pumping plants is done away with, and in locating a supply of water to be taken from an underground source the wells can be placed without particular reference to the power plant, and where, and at such distances apart, as will best maintain the highest average pumping level.

Free Condensing Water for Water Works

There is perhaps no other situation in mechanical engineering where so great a saving in fuel consumption can be effected with so small an investment as by the use of a condenser in water works plants operating piston pumps and air compressors. Usually no extra expense whatever is incurred for pumping the water for condensing, as a part of that regularly handled by the plant can be passed through the condenser before it is pumped into the service mains.

The total amount of water handled by such a plant is so great in proportion to the amount needed for condensing purposes that the increase in temperature is of trifling importance compared to the saving in fuel effected.

As an example, we cite a plant installed by this company in north Texas, consisting of a Corliss air compressor having both steam and air cylinders duplex cross compound. This is lifting water more than **300 feet vertically** from three drilled wells. The additional lift into the standpipe by the piston pump is over 100 feet more. Still, under even these severe conditions, both the compressor and pump are run condensing, and the saving in fuel pays for the condenser every few months. The temperature of the water in the standpipe is raised so little that many citizens on being questioned stated that they had noticed no difference.

It Pays to Pump Water Especially for Condensing Purposes

Let us look into this question a little further by using actual figures. We will assume in one case a 100 H. P. simple non-condensing engine, in first-class working order, so that it runs on a steam rate of 36 pounds per horse-power hour and supplied with steam from a first-class boiler plant giving an evaporation of 9 pounds of water per pound of coal, equal to 4 pounds coal per horse-power hour. To make a severe case, we will assume that this plant will run but 10 hours per day and 300 days, or 3,000 hours per year. This gives an annual coal consumption of **600 tons.**

The extra power required to operate an air compressor to pump condensing water for this plant, even lifting it as much as 75 feet vertically, would be under 10 H. P.; but say 10. This makes a total horse-power required of 110. But the reduction of the coal consumption by running condensing would be from 25 to 35 per cent.; but say only 25 per cent.; or to a coal rate of 3 pounds per horse-power hour. One hundred and ten H. P. at 3 pounds gives an annual coal consumption of **495 tons,** or a saving per year, at the lowest estimate, of **105 tons.** At $3 per ton this is 10 per cent. on $2,100—far more than the usual cost to make the change.

If the above should be considered a case specially favoring the application of a condenser, we will take another case, already assumed to be a fairly economical plant, having a 500 H. P. compound non-condensing Corliss engine, or compressor, running only 3,000 hours yearly, steam rate 22½ pounds and evaporation of nine to one, as before. This would require annually coal amounting to **1,875 tons.** Adding 10

per cent., as before, for power to lift condensing water, gives as the total power 550 H. P. In this case we will only assume that the condenser brings the water rate down to 18 pounds, or a reduction of 20 per cent., giving a coal rate of 2 pounds per horse-power hour. Five hundred and fifty horse-power at 2 pounds coal gives yearly coal required as **1,650 tons.** Yearly saving in coal, **225 tons,** or, at $2 per ton, 10 per cent. interest on $4,500—far more than the usual cost of equipping with compressor and condenser.

No extra labor is required, as the compressor can be located in the engine room and looked after by the old force. But there is a saving of over 10 per cent. in the handling of coal and ashes and a reduction of the work required of the boiler plant.

If an evaporation of 7 pounds of water per pound of coal is taken as the basis of figuring (and this is nearer the average) and the plant runs more hours per year, the saving can easily be made three times the above figures. Again, it is not usual that it would be necessary to lift the water as much as 75 feet vertically, as water suitable for this purpose can usually be found nearer the surface.

Another instance of the material saving in fuel consumption as a result of pumping water especially for condensing purposes may be found in the experience of the Husted Milling Company, of Buffalo, New York. An 8-inch well was drilled to a depth of 325 feet, when a strong stream of water was reached. The water rose to such a height in the well that when pumping 400 gallons per minute the lift to the surface was 50 feet. It was quite cold, the temperature being about 50 degrees, and so impure that it could be used for no other purpose than condensing.

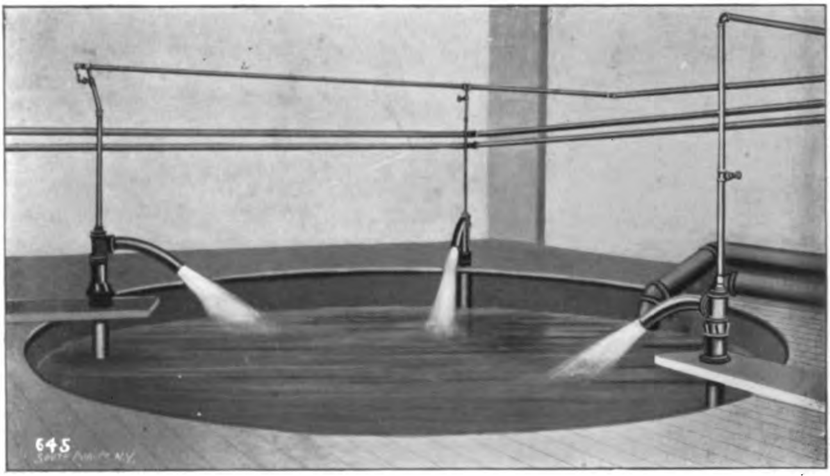
This company had a 26 x 48-inch Corliss engine, the load on which was about 600 H. P. Steam was furnished by three return tubular boilers, two of 100 and one of 140 H. P. capacity. A low pressure steam cylinder, 52 x 48 inches, was added to the engine, making it tandem compound. A jet condenser giving a good vacuum was also installed.

Since this change, despite the fact that they have been compelled to reduce the steam pressure to 100 pounds on account of the age of the boilers, these same boilers are doing the same work, and in addition are also furnishing steam for the condenser and to operate a 12 and 14¼ x 14-inch Class "A-1" Straight Line air compressor, which is used for the Air Lift. Only one fireman of the two employed heretofore is now needed, while the coal consumption has been cut from 8 tons to less than 4 tons for a 15-hour day. The change has further resulted in increasing the H. P. of the engine by about 150. Altogether the saving is summed up at from $3,000 to $3,500 per year.

garding the underground water supply, we will probably be able to make you a proposition that will show a clear saving of from 15 to 50 per cent. of your fuel bill, at an additional cost that will show **a return on the investment of from 10 to 50 per cent.**

Sand Is No Obstacle

Almost all wells are troubled to a greater or less extent with inflowing sand. This sand, mixing with the water, cuts out suction and deep well pumps in a very short time, causing much annoyance, de-



A Central Discharge from Several Air Lift Wells.

lay and expense. It has no effect on the Air Lift, however, as sand and gravel in the water form no obstacle and do not interfere with its action. This was demonstrated very effectually at the Charleston, S. C., water works, where over 200 tons of quicksand were pumped from a single well. At another place several cartloads of pebbles and stones were pumped out of a well using 3-inch water pipe, some of the stones being 2¼ inches in diameter by 4 inches long. At the Charleston station, the piles of sand were 8 feet high in places and extended over much of the yard. This is a deep well, sunk at great expense, and originally yielding but 103 gallons per minute. Two months' pumping with the Air Lift exhausted the quicksand, when the well yielded 250 gallons per minute of pure and clear water. In this case there is another well a mile away which starts and stops with the compressor without attention.

Economy Compared with Other Systems

It is natural that at first the Air Lift System should have been lacking in the efficiency now possible. Its rapid growth in favor everywhere shows a foundation of solid merit and an adaptability to certain conditions which no other pumping system can meet so well. Some have thought the system lacking in economy, but their judgment rests on results obtained with improper methods of well piping in connection with inefficient compressors, from which satisfactory results on a "foot-pound duty" standard could not be expected.

The superior air compressor of to-day operates with a half or quarter of the fuel for a given power formerly required. Refinements in well piping and a better understanding of conditions have reduced both the pressure and the volume of air needed. There are now so many successful plants at work, meeting all the different conditions of volume and lift, that the design is reduced to a scientific basis.

An Air Lift test was recently made in Indiana which affords an opportunity for comparison between the efficiency of the Air Lift System of pumping and one of the best and most economical deep well pumps made.

This Indiana water works for over a year used a second-hand 16 & 18¼ x 18 inches Class "A-1" Ingersoll-Rand compressor to operate an Air Lift furnishing a temporary water supply. Recently the pump company obtained permission to make a test, and installed two of its belt-driven pumps, with cranks and pitman, giving a double acting effect with a definite length of stroke.

In this case the pumps were driven by an ordinary portable engine and boiler. The test was conducted by a well-known consulting engineer, who was employed by the city to make tests to determine which system should be adopted. As a result of these tests, which were very thoroughly made, it was definitely shown that the deep well pump raised 60 gallons of water per pound of coal burned under the boiler, while the Air Lift plant, under the same conditions, raised 300 gallons per pound of coal burned.

These tests were unbiased and reliable, and afford an idea of the relative efficiencies under like conditions. Admitting a much higher efficiency for the pump in cases where economical engines are used, it should also be borne in mind that the efficiency of the Air Lift plant can be increased by using Corliss compound compressors, and that a power-driven deep-well pump such as was used in this case is much more efficient than the more usual type, which is driven by a direct-connected steam head, so that the comparison would be about the same for average conditions.

Air Lift Discharge at Cotton Mill in Mexico City, Mexico.

Cost of Pumping with the Air Lift

This question is usually asked without giving several items which largely determine the answer. Thus, coal at $2 is one thing, at $4 another. Again, some wells are nearby and in other plants the pipe investment is greater because of scattered wells. When furnished with full data we can usually state the cost very closely, and a comparison with the present cost will often show a saving sufficient to pay for the outfit in from one to three years.

Speaking generally, the average cost per thousand gallons pumped depends on the size of plant and height of lift. In a 4,000,000 gallon plant, with a 50-foot lift, it is about ⅓c. per 1,000 gallons. In a larger plant, with a 35-foot lift, with coal at $2, it is about 1½ mills. In another case, where the lift is 75 feet and the capacity 1⅓ million gallons, the cost is 1c. per 1,000 gallons, coal costing $2. In a plant pumping 3,000,000 gallons 75 feet high, the cost is 4½c., and where the lift is 50 feet, 3½c. In Pennsylvania, a plant giving 175 gallons per minute at 75-foot lift, costs 1⅓c. per 1,000 gallons. In a proposed municipal plant, 100,000,000 gallons per 24 hours, 50-feet lift, and with coal at $1.50 a ton, the cost figured 1 mill or $\frac{1}{10}$c. per 1,000 gallons, including all fixed and operating expenses.

In another case, involving the handling of about 15,000,000 gallons of water 30 feet high every 24 hours, using compound condensing compressors, and with coal at $2 per ton, other figures being estimated on a very generous basis, the cost nets about $2.50 per 1,000,000 gallons, or about 2½ mills per 1,000 gallons. These figures cover fuel, oil, labor, sinking fund, interest and taxes.

In one New Jersey plant, yielding 1,750 gallons per minute, the use of Ingersoll-Rand Corliss Air Lift machinery has doubled the quantity of water with only one-half the fuel formerly required by another make of compressor.

In many cases the introduction of the Air Lift may be effected at little expense, often involving the purchase only of an air compressor, a receiver, and a small amount of pipe, but the following is estimated on a basis which will cover the greatest amount of expense likely to be incurred, with a view of showing particularly that the interest and depreciation charges under the most extreme conditions are not likely to develop into formidable figures. The following is a list of the complete equipment for an Air Lift plant to raise 1,500,000 gallons per 20 hours, or 1,250 gallons per minute. Total lift, 75 feet:

Air compressor, complete, ready for foundation and piping.
Air receiver.
85 H. P. of boiler, with feed pumps, etc., bricked up and ready for use, including building and value of ground so occupied.
Tank, say 19,000 gallons capacity (15 x 14 ft. 6 in.), including suitable timber framework to bring tank 75 feet above water level.
Two 12-inch wells, each 135 feet deep, cased.
450 feet 7⅝-inch light casing (water discharge pipe).
500 feet of 3-inch casing (air pipe in wells).
1,000 feet of 4-inch air line from receiver to wells.
1,250 feet of 12, 10 and 8-inch cast iron distributing main, leaded joints, from tank to works, laid below frost (air line laid in same trench).
All other pipe and fittings.
Compressor, receiver and tank foundations, say 18,000 bricks, laid in cement.
Excavation for foundation, say 75 cubic yards.
Special automatic governing mechanism.

Total estimated cost of complete plant, ready to run, as above $8,750.00.

This is intended to include everything which may be considered as a legitimate expense in this connection. In many cases the buildings, boilers, tanks, wells, pipe lines, ground space and other items do not represent a present expense, being already on the ground.

From the following figures we may estimate the cost of operation, as follows:

Cost of Operation

Engineer, double shift, at $2.25 per day, $4.50; ⅕ time chargeable to pumping plant, per day........................	$0.90
Fireman, double shift, at $1.75 per day, $3.50, on the basis of one man required for each 250 H. P. of boiler for 85 H. P. per day..	1.19
Fuel, 85 H. P., 20 hours, say 4¼ tons, at $2 per ton, per day.	8.50
Oil, waste, and sundries, say..............................	.60
Interest on investment of $8,750 at 5 per cent., figuring eleven 25-day months, or 275 working days per year, per day.....	1.91
Deterioration, covering sinking fund, repairs, etc., providing for renewal of complete plant every ten years same basis as interest but 10 per cent., per day......................	3.18
Insurance and taxes at 1 per cent., as above, per day.........	.32
Total estimate cost of pumping 1,500,000 gallons per day, 75 feet high, under the above conditions..................	$16.60

Cost of each 1,000 gallons ($16.60 ÷ 1500), $0.01107.

Kent, quoting the National Meter Company as authority, gives the cost of water in the States as follows:

Average minimum price per 1,000 gallons in 163 places, .094.
Average maximum price per 1,000 gallons in 163 places, .28.
With extremes ranging from 2½c. to $1 per 1,000 gallons.

As a usual thing the water rate in most manufacturing cities in the Central States runs in the neighborhood of 8c. to 10c. per 1,000 gallons supplied. In some of the larger Eastern cities it runs up to 12½c., and even higher, and in some cities of the second and third class goes as low as 5c. per 1,000 gallons. At 5c. per 1,000 gallons the yearly water bill on the above basis amounts to.................$10,625.00

And at the figures given above, $0.01107................ 4,566.37

A yearly saving on the above basis of..................$ 6,058.63

Saving Effected

This equals a profit of 69⅕ per cent. on the estimated investment of $8,750.00, or is the same as a dividend of 20 per cent. on an investment of $30,293.15. With the actual cost of the plant less than is figured above, as it would really be in the majority of cases, the saving would be still greater. In many cases the operation of the plant does not involve the extra expense of engineer and fireman, and these items may be deducted. In other instances the fuel cost, either through the use of high duty air compressors or through lower cost of coal, may

amount to much less. The only other items which amount to much are those of interest and deterioration, and we have already seen that these have been taken on the outside extreme. In a plant pumping about 3,000,000 gallons per 20 hours, 75 feet high, where the cost of the fuel delivered is 85c. a ton, but the other expenses are figured even more liberally than is shown by the preceding estimate, the cost per 1,000 gallons is about $0.0084.

And in the same case, but pumping 50 feet high, about $0.006.

Small Plants Also Economical

As the figures given may give the impression that the cost of pumping with a small plant may run disproportionately high, we will investigate in that direction also. In most small plants an inexpensive belt or steam actuated compressor may be used, entailing no additional attendance expenses and no extra boiler, building or tank investment, and in some cases there would be no additional cost for well, etc. Belted compressors will often bring an underloaded engine up to an economical point. Excluding tank, boilers and building, but making proper allowance for well, piping, steam-driven compressor, receiver, foundation, freights, erection, etc., assuming that the tank and well are close to the work, we find that for a plant to pump 175 gallons per minute, or 352,000 gallons per 24 hours, 75 feet high, the total investment is not likely to exceed $1,500. The interest, deterioration, insurance and tax charges, as above, aggregating 16 per cent., net, on this sum per day $0.87

A proportionate allowance for fuel at $2 per ton, attendance, oil, etc., should not exceed per day 2.50

Total cost of pumping 252,000 gallons per day $3.37

Cost per 1,000 gallons .... .01⅓

Cost of this amount of water at 5c. per 1,000 gallons per year of 275 days $3,465.00

And at 1⅓c. per 1,000 gallons 924.00

Net saving effected per year with a plant costing $1,500...$2,541.00

or a dividend of 169 per cent. on the investment. Certainly one had better borrow the money rather than neglect such a saving as this. In many instances a surprising saving may be effected when the water is now being obtained by means of deep well pumps by throwing the outfit aside and installing the more economical Air Lift System.

The cost per 1,000 gallons is not always the most important matter.

In municipal supply, quality is important beyond all considerations of cost.

In some cases water of inferior quality is being used at a considerable disadvantage because of its accessibility. In one instance river water, highly impregnated with sulphur coming from coal mines above, resulted in an expense of $5 to $8 per day from the grooving and pitting of rolls in a steel-working establishment. The effect on the boilers was very bad and represented an important item of expense in repairs and extra fuel burned. In such a case as this it might be well to go off even a mile to sink wells in some desirable location, the superior quality of the water so obtained reducing in many ways the cost of manufacture. In this case the lost output through pitted rolls, shut downs, injury to plant, or the increased rolling capacity with cold water and saving in boilers cannot well be expressed in dollars.

In some instances deep well pumps have been thrown out and the Air Lift installed, primarily because of the thorough aeration of the water resulting in throwing off most of the sulphur and other objectionable qualities.

Again, with a copious and inexpensive water supply, condensers may be attached to the main engine, resulting in a saving of 20 to 30 per cent. of the whole fuel bill.

Air Lift Plant in an Indianapolis Brewery.

LIMITATIONS OF THE SYSTEM

Quantity Unlimited

There is no limit as to the quantity that can be handled, except the capacity of the wells to furnish the water.

Distance Unlimited

With a properly designed piping system the loss of power in the transmission of compressed air is trifling, and compares very favorably with any other method. It varies practically as the distance—that is, the loss in four miles is approximately twice that for two miles, with the same size pipe. With electricity the loss would be four times, or as the square of the distance.

As the Air Lift pump is automatic in its action there is no objection to having the source of water supply at a distance from the power station.

There are successful plants in the oil country where areas of ten square miles are supplied through over forty miles of air lines from one central plant. It is claimed that one of these burns 85 per cent. less fuel than was formerly required for the 375 working wells operated.

Height of Lift Unlimited

There seems to be a prevailing idea that the Air Lift system is not adapted for lifts of much more than about 200 feet vertically, but this is far from being well founded. We have more than twenty plants in one oil field pumping a mixture of salt water and oil on actual lifts of from 600 to 1,200 feet, in most cases with an air pressure of less than ⅓ pound per foot of actual lift, and in some cases less than ¼ pound.

In the Rocky Mountains there is an Air Lift working at a mine, taking air from a high pressure pneumatic locomotive service main and lifting 160 gallons of water per minute, more than 700 feet vertically.

All the air that this pump gets passes through a $\frac{5}{32}$-inch round hole drilled in a solid plug cock.

These are regular Air Lift plants, without any valves or working parts in the well.

Especially Adapted for Very High Lifts

The fact is that the Air Lift pump, as improved and installed by this company at the present time, is especially adapted to very high lifts, because it is under these conditions that all forms of deep well pumps give the most trouble from broken rods, valves, and pipes, and the lowest efficiency, owing to friction and leaking leathers and valves.

We are prepared to furnish proposals for furnishing Air Lift outfits specially designed for **any lift no matter how high,** so long as there is a reasonable amount of submergence available.

Submergence Limits

The percentage of submergence means the percentage of the **total vertical air lift column** (measured vertically from the point of air admission at the bottom to the point of water discharge at the top) which is submerged in the solid liquid column in the well **when pumping.**

Neither the liquid level in the well when not pumping, nor the depth of the well, nor the level of the surface of the ground necessarily affects the submergence percentage, because when the pump is started the liquid level may fall 2 feet or 200; the point of discharge may be 10 feet below the ground surface *or* 100 feet above; and the well may be 1,000 feet deep, with the pipes extending only 200 feet down.

For example, with a well 800 feet deep, pumping water level 300 feet below, and point of discharge 100 feet above the surface, the pipes extending 700 feet below the ground surface, the total vertical height of the column is 800 feet, and the submergence 400 feet or 50 per cent. We have plants working satisfactorily, under special conditions, on less than 30 per cent. submergence, and some with over 75 per cent., but the best economy is attained when the lift and submergence are correctly proportioned.

However, before you abandon a hard proposition as hopeless, or continue to suffer constant expense from breakdowns, let us tell you what compressed air will do.

We have installed a large number of successful municipal plants, too many to undertake to give a complete reference list here. Those interested will be referred to the nearest similar plants on request. We have put in so many plants under all conditions that our methods of economical plant arrangement will be of the greatest value to our clients.

We have connections with responsible and successful well experts and erecting engineers, and are thus in a position to arrange for complete plants, furnishing the right system of well piping for given conditions and not being limited to the use of obsolete piping systems, narrow in their proper range of use. Air Lift pumping is a specialty, and much depends upon an accurate understanding of the well and water bearing strata, so when asking for quotations, inquirers should closely follow the question sheet at the back of this catalog, and define clearly what conditions are to be met.

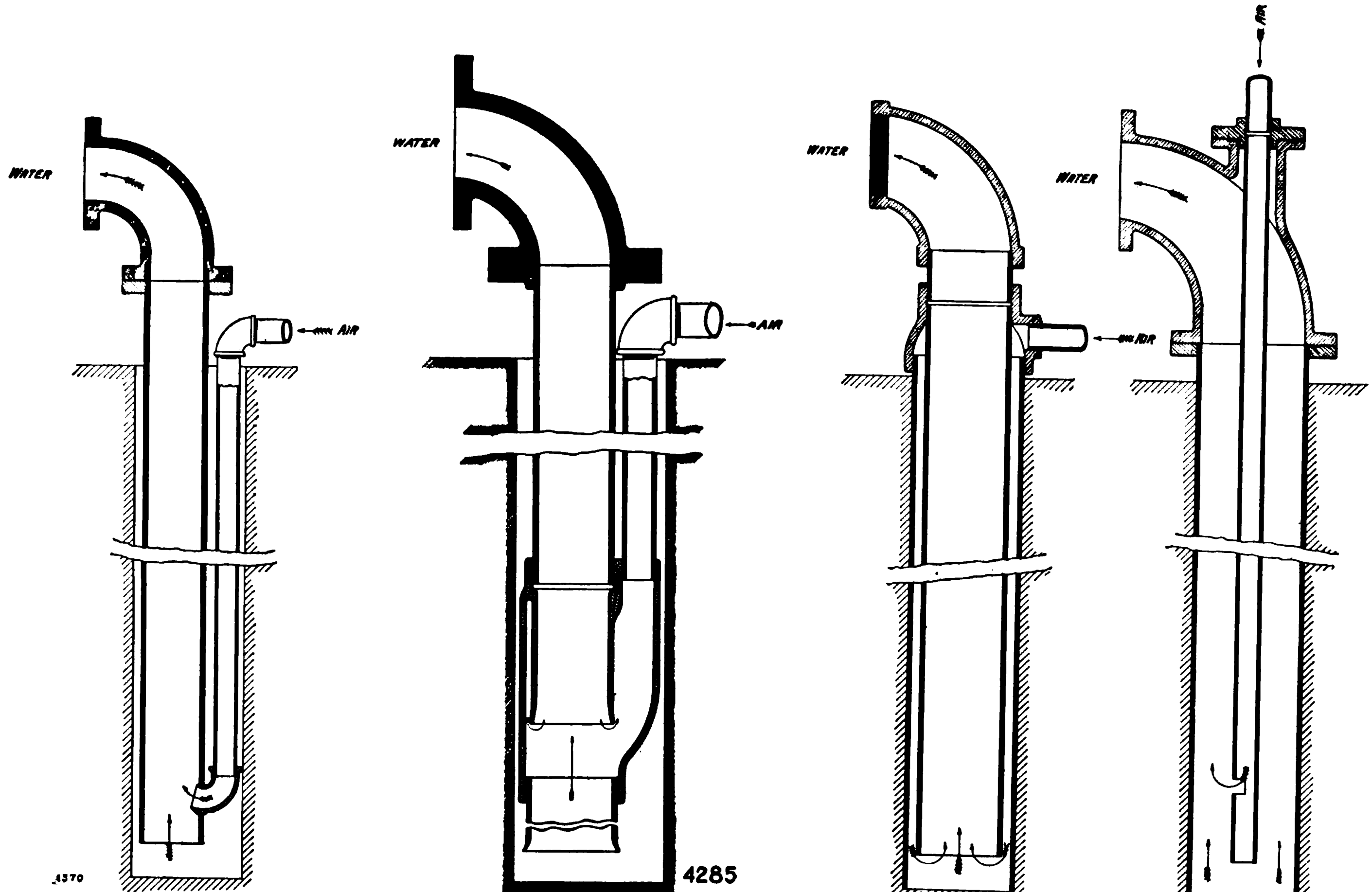


Fig. 1 Fig. 2 Fig. 3 Fig. 4

Methods of Piping Wells.

METHODS OF PIPING WELLS

All wells are not alike, and consequently the method of piping which might properly be applied to one would be unsuited to another. Each well represents a problem requiring special study. We are peculiarly well situated for solving such problems, because of our large experience in installing the Air Lift System all over the world. It is our fixed policy not to recommend the adoption of the Air Lift unless we are convinced that it will pay the customer to use it. On the previous page are shown four distinct methods of well piping, each differing from the others. Each has its uses, and will only operate most efficiently and economically under certain conditions.

Of these methods of piping, we apply that which will operate with the greatest economy, depending upon the conditions, the height of lift, the volume of water, as well as the depth of casing, nature of well strata and other considerations. There is a great variation in results with the same method, if conditions differ, and piping which will work well in one case will give entirely different results elsewhere, though to the novice the conditions seem identical.

Method No. 1. Pohlé Air Lift.—Fig. 1

In the Pohlé or Side Inlet, shown in Fig. 1, the air and water pipes are placed alongside of each other in the well, and connected at the bottom with an end piece. This method should be used when the well is sufficiently large to admit of the air and water pipes being placed side by side from top to bottom. This is the most economical system, and its advantages are marked at medium and high lifts.

We make standard side inlet devices or foot pieces and clamps for this type as follows:

Air Pipe Connection.	Water Pipe.	Size Well.	Maximum Economical Capacity on Moderate Lift.
½ in.	1 in.	3 in.	7 gallons per minute.
¾ in.	1½ in.	4 in.	20 " " "
1 in.	2 in.	4½ in.	35 " " "
1 in.	2½ in.	5 in.	60 " " "
1¼ in.	3 in.	6 in.	90 " " "
1½ in.	3½ in.	7 in.	120 " " "
1½ in.	4 in.	8 in.	160 " " "
1½ in.	5 in.	9 in.	250 " " "
2 in.	6 in.	10 in.	350 " " "

Larger sizes furnished to order.

The size of air pipe in well depends upon its length, and the volume and pressure of air to be used.

In cases of necessity the capacities given can be increased 20 to 40 per cent., but at a decreased efficiency in operation, this depending upon the height of lift and other conditions. Under some conditions, the given capacities have been doubled.

Method No. 2. Pohlé Air Lift.—Fig. 2

Another adaptation of the Pohlé System is shown in Fig. 2. This is the Pohlé-Annular Foot Piece, a special device for connecting the air and water pipes, and for the proper admission of air to the rising column.

Compressed air fills the annular space or ring surrounding the uptake pipe, and is free to enter the rising column at all points of its periphery, at the same time acting without obstructing or contracting the discharge pipe anywhere. The material is high grade composition, especially designed for strength and to withstand the action of bad water.

We make these foot pieces in the following stock sizes:

Telegraph Name.	Size No.	Well.	Pipe Sizes.			Max. Economical Capacity, Moderate Lift.	Dimensions	
			Disch.	Air.	Tail.		Outside Diam.	Length.
POHLEABADO	X154	4 in.	1½ in.	½ in.	2 in.	20 G. P. M.	3 11/16 in.	11 in.
POHLEABAIS	X155	5 in.	2 in.	¾ in.	2½ in.	35 " " "	4 15/32 in.	12 in.
POHLEABARE	X156	6 in.	2½ in.	1 in.	3 in.	60 " " "	5½ in.	12½ in.
POHLEABBIO	X157	6 in.	3 in.	1 in.	3½ in	100 " " "	5⅞ in.	13 in.
POHLEABEGA	X158	6 in.	3½ in.	1¼ in.	4 in.	140 " " "	5 15/16 in.	13 in.
POHLEABEM	X159	8 in.	4 in.	1½ in.	4½ in.	190 " " "	7⅝ in.	13½ in.
POHLEABEOR	X160	8 in.	4½ in.	1½ in.	5 in.	225 " " "	7 9/16 in.	13½ in.
POHLEABICA	X161	10 in.	5 in.	1½ in.	6 in.	300 " " "	9⅜ in.	14 in.

Column "Maximum Economical Capacity" is based on 60 per cent. submergence and a discharge of 12 gallons of water per minute per square inch area of discharge pipe in the smaller diameters, and 15 gallons per minute per square inch in the larger sizes.

General Notes

As the lift increases the necessary ratio of submergence to lift decreases.

For a given lift and quantity of water the necessary size of discharge pipe increases as the submergence decreases.

Diameter of air pipe depends upon the quantity of air required and its pressure. Air pipe sizes listed are the standard openings in the foot pieces. The air pipe used can be of larger or smaller diameter by using suitable reducing fittings.

A tail, or drop, pipe below the foot piece tends to steady the flow, and prevent the water "backing up" or reversing in the well casing. Use a full length, 18 to 20 feet, wherever possible, down to 4 feet, depending upon depth of well.

Method No. 3. Saunders Air Lift System.—Fig. 3

In some instances a well does not admit the use of the side inlet system, when the Saunders air lift system may be used. A central tube is suspended inside the well while the air passes down between it and the well casing. The water is then discharged through the central tube, as shown in Fig. 2.

In estimating the capacity of this system it is usual to allow quantities as follows:

Height of Lift.	Gals. of Water per min. per sq. in.—Area Water Pipe.
25 ft.	15 to 20 gallons to each square inch area of water pipe
50 ft. to 125	12 to 15 " " " " " " " " "

In the case of salt wells with a natural flow, or those in which water is pumped down to dissolve the salt, and later is raised as brine, we advise the use of this system. See special mention of this subject on page 36.

Method No. 4. Central Air Pipe System.—Fig. 4

The third or central air pipe system reverses the arrangement already described, and is used to obtain the greatest possible output for a given size of well-casing. The air pipe is suspended inside. The air passes down this central pipe, the water and air discharging between the air pipe and the well casing. The size of the air pipe depends on length and volume of air it is to carry and pressure. This is not always as economical as 1 and 2, but may be used where the well is very strong and a great deal of water is wanted from a few wells.

The proper size of air pipe for different sized casings and the capacity to be expected are about as follows, depending on the lift and submergence:

Size of Casing.	Size of Air Pipe.	Capacity.
3½ in.	1¼ in.	80 to 100 gallons per minute
4 in.	1½ in.	100 to 150 " " "
5 in.	2 in.	150 to 250 " " "
6 in.	2 in.	275 to 375 " " "
8 in.	2½ in.	500 to 650 " " "
10 in.	2½ in.	775 to 1000 " " "

Compound Air Lift

Where a part of the water only is used at a high elevation about the works, it is an easy matter to put in a supplementary air lift, taking its supply from the distributing main and raising it in a second or compound lift to the point desired, thus avoiding the expense of raising the whole volume of water to the full height.

When wells are shallow, not large in capacity, and the lift high for the submergence under ordinary methods, we have secured successful "compound" results by raising the water to the surface, allowing it to flow by gravity into a specially constructed well near the tank, thus supplying the necessary submergence to give the higher tank delivery.

The most common way of providing for making lifts above the surface where the conditions in the well, or wells, do not permit a direct lift is to collect the discharge from the wells by gravity at some central point and make the required lift above surface by means of an ordinary pressure pump. This method is particularly advisable in cases where the discharge from the wells can be returned by gravity to the power house or vicinity, thus allowing the steam or power pump mentioned to be set up in the same building with the air compressor.

Another common and acceptable method is to make the lift above surface and do any horizontal forcing necessary by means of a pneumatic displacement pump, which, under general conditions in plants of this kind, is found to be the most desirable way of delivering the water, as it means that the whole pumping operation from wells to tank is done through the medium of compressed air.

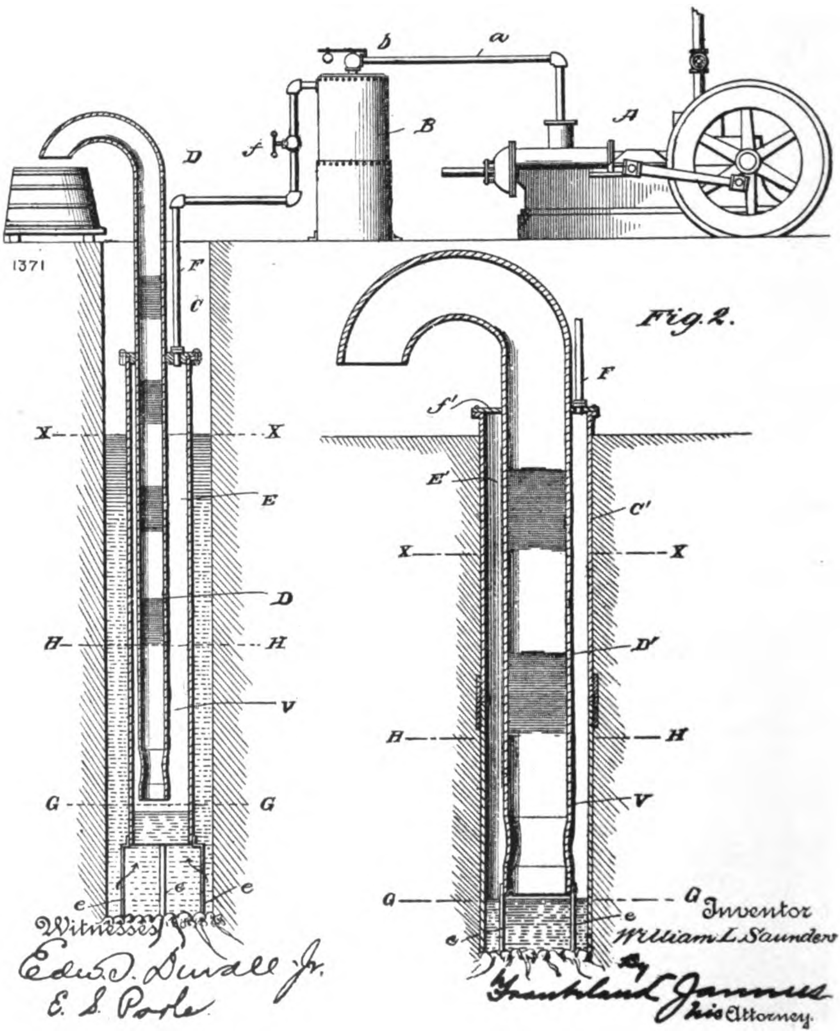
Each of these has its special field of utility, and a choice should not be made without a full knowledge of conditions.

Air Lift Irrigation Plant on Rice Plantation, Trilby, La.

W. L. SAUNDERS

Air Lift Pump

No. 597,023. **Patented Jan. 11, 1898.**



THE SAUNDERS AIR LIFT SYSTEM.

Differing in several important features from the Air Lift patented by Dr. J. G. Pohlé, Mr. W. L. Saunders has patented a system in which the discharge takes place through the central tube which is at all times surrounded by compressed air. Referring to the illustrations from Patent No. 597,023, as shown on the opposite page, the operation of the device is as follows:

Compressed air, produced from any source (A), passes to the well (C) and into the air-tight chamber (E), formed by the outside pipe, which may be either the casing of the well (Fig. 2) or an inserted pipe resting on the bottom of the well (Fig. 1), but open to permit free ingress of water. Extending down into the casing, but not quite to its bottom is the discharge pipe (D). There are no valves, rods, pistons or working parts, and no features other than those mentioned. Pipes must, however, be properly proportioned to obtain the best results.

The space between casing and discharge pipe is obviously termed the "Pressure Chamber." When idle, without air pressure, the water will stand at the normal ground level in both the pressure chamber (E) and discharge pipe (D). As the air pressure in (E) is increased the water is gradually forced down and back into the well until the end of the discharge is uncovered. Instantly a portion of the air escapes into the discharge pipe (D). This lowers the pressure in the chamber (E), and immediately the water rushes in and up the pressure chamber (E) and discharge pipe (D) to some point (HH) before the water and air pressure balance, when the water is again forced out, the air as before escaping through the discharge pipe. This time, however, the air in rising and expanding pushes before it that quantity of water which just previously had rushed into the discharge pipe. This water was already in motion, and had a certain velocity upward. To in-increase this velocity the discharge tube is restricted and ormed into a "venturi" near the bottom, a method materially assisting to start the water up the eduction tube.

In operation, the surface of the water in the pressure chamber is pulsating up and down past the bottom of the discharge pipe. Entering the tube as a solid column of water with considerable velocity, each wave is followed by a definite volume of compressed air, and rushes up the central pipe (D) in a series of water plugs or pistons. The air by the time it reaches the outlet has expanded to about atmospheric pressure. The air cannot escape past the solid moving pistons of water, and, therefore, each cubic foot of air exerts all its contained energy in useful work. Of especial utility is this form for cases where corrosive liquids, such as brine solutions, are to be raised.

CLAIMS FOR THE SAUNDERS AIR LIFT

The claims for the Air Lift, invented by Mr. W. L. Saunders, are given in the patent as follows:

1. The herein-described method of pumping, which consists in supplying directly to the open lower end of a valveless delivery pipe surrounded by an open-bottom chamber continuously supplied with a gas under pressure, of charges of the liquid and of the gas under pressure and in alternation.

2. The method of pumping, which consists in supplying to the open lower end of a valveless delivery pipe surrounded by a submerged pressure chamber having its lower end permanently open to receive the liquid and continuously supplied with a gas under pressure, of charges of liquid and of gas at a high velocity and in alternation.

3. In a pumping operation the process of raising liquid, which consists in supplying to a pressure chamber permanently open at its lower end to receive the liquid, and provided with a downwardly-extending delivery pipe, also open at its lower end, said lower end located near the opening of the chamber, of compressed air at a point near the upper end of the pressure chamber from a constant source of supply admitting liquid to the open end of the chamber and of the delivery pipe under sufficient momentum to force itself into the delivery pipe and also to cause an increase of the pressure of the compressed air in the upper part of the chamber, until the momentum of the water entering the chamber is overcome thereby, when the water is forced down and out of the chamber into the well, and the excess of air pressure allowed to escape up the delivery pipe, forcing the water before it, and vice versa.

4. The combination with a well to be pumped, of a delivery pipe, the lower end of which is open to receive the water and which extends below the normal water level, a pressure chamber surrounding said delivery pipe, and permanently open at its lower end to receive the water, connections between the upper part of the pressure chamber and an independent source of compressed air or other gas, whereby, under the variations of pressure in the chamber due to the momentum

of the head of water and the escape of part of its contents, the air and water will pulsate above and below the mouth or exit of the eduction pipe, and portions escape thereinto alternately.

5. The combination with a well, of a pressure chamber closed at its upper end and permanently open at its lower end to permit free inflow of water, of a delivery pipe arranged within the pressure chamber and extending below the normal water level, and open at its lower end to receive the water from the well, and an independent source of compressed gas connected with the upper end of the pressure-chamber, whereby under a constant flow of gas under pressure from the independent source into the pressure chamber the gas and liquid will pulsate about the lower end or mouth of the delivery pipe, alternately entering the same.

6. In an air-lift pump the combination of a delivery pipe extending below the normal water level, a pressure chamber inclosing part of said delivery pipe and extending down below the lower or inlet end thereof, and permanently open at its lower end to receive the water connections between the upper part of the pressure chamber and an independent supply of air under pressure, and means for regulating the pressure of air supplied to the pressure chamber.

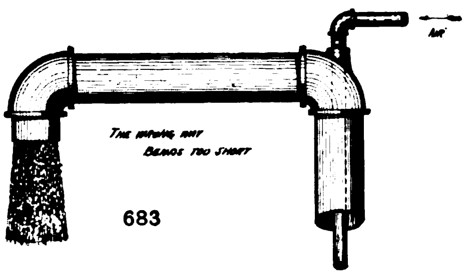
7. In an air-lift pump the combination of a stationary delivery pipe formed with a contracted portion near its lower extremity, a pressure chamber surrounding said pipe, said chamber permanently open at its lower end to receive the water, and valveless connections between the pressure chamber and an independent source of compressed air at one end, and with the water at the other end, whereby the head or normal level of the water in the well and the pressure of air from the tank will always oppose each other in the pressure chamber, causing them to pulsate above and below the lower end of the delivery pipe, air and water escaping thereinto in alternation.

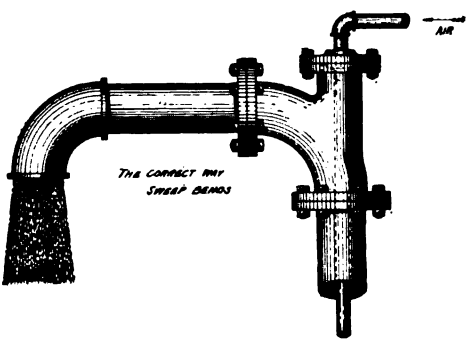
8. In an air-lift pump, the combination of a delivery pipe formed with a contracted portion near its lower end or mouth, a pressure chamber surrounding said pipe and permanently open at its lower end to receive the liquid and supplying compressed air thereto from above in alternation with the supply of liquid, and connections between the pressure chamber and an independent source of compressed air.

ARRANGEMENT OF WELLS AND PIPING

Proper piping up of wells is a feature counting largely in the success of an Air Lift system, whether working one or several scattered wells. The introduction of unnecessary valves, elbows, angles and bends will cause a loss of air pressure, cut down the efficiency of the plant very largely, and should be avoided as far as possible.

It is therefore well to lay out beforehand the wells and piping, placing the wells and reservoir so that pipes can be run direct, with the fewest possible bends, elbows and valves. Pipes should all be made of a size sufficient to carry air to the wells and the water away with the least practicable resistance.





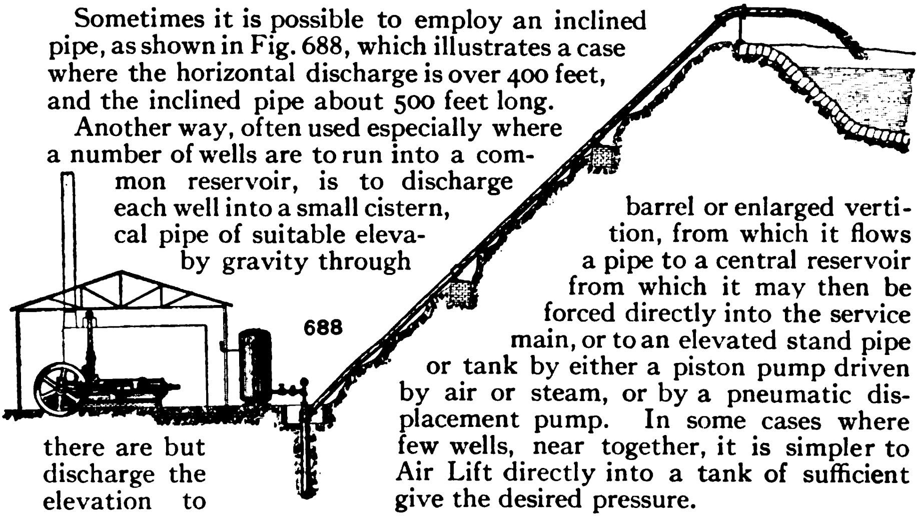
The tables given on pages 48 and 49 afford a means of determining the sizes of pipes necessary to transmit a given volume of free air with a predetermined drop, or conversely, the reduction of pressure which will occur in a given length where a certain size pipe is used. To the actual lengths, as measured from plans, or on the ground, should be added the increase or allowance for valves, tees and elbows, as given in the table, page 49.

It is for this reason that the use of long sweep elbows and tees is recommended, especially for water. In many cases elbows can be avoided by making long bends of pipes. If this is done the bends should be made smooth, regular and free from dents or kinks.

In laying out and piping up an Air Lift system the horizontal distance to which the discharge is conveyed by air should be made as short as possible. Wherever possible the water should be elevated at the well high enough to give a slight fall toward the point of discharge. Horizontal runs involving subsequent lifts are always designed to meet the special conditions.

Sometimes it is possible to employ an inclined pipe, as shown in Fig. 688, which illustrates a case where the horizontal discharge is over 400 feet, and the inclined pipe about 500 feet long.

Another way, often used especially where a number of wells are to run into a common reservoir, is to discharge each well into a small cistern, barrel or enlarged vertical pipe of suitable elevation, from which it flows by gravity through a pipe to a central reservoir from which it may then be forced directly into the service main, or to an elevated stand pipe or tank by either a piston pump driven by air or steam, or by a pneumatic displacement pump. In some cases where there are but few wells, near together, it is simpler to discharge the Air Lift directly into a tank of sufficient elevation to give the desired pressure.



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Carry as Low Air Pressure as Possible

When running several wells together which require different air pressures, engineers sometimes put throttle valves on all the wells and in regulating them too finely raise the receiver pressure to a point far above that required to run the highest pressure well. All this excess pressure represents power thrown away, and the practice should not be allowed. It is in such cases necessary to have throttle valves on all the low pressure wells and to often have them nearly shut, but the well that requires the highest pressure to operate it should be run with the valve wide open, or nearly so, and then the other wells regulated to take what air they need, forcing the rest of it to the high pressure well.

An ordinary globe valve proves to be the best regulating valve except for very high pressures. Gate valves or plug cocks cannot be regulated as closely and cannot be so readily set at the same point after having been closed. A second globe valve may be used for stopping and starting, thus leaving the economical adjustment of the regulating valve undisturbed.

The brief descriptions just given call attention to a few working combinations, but by no means exhaust the arrangements which can be made. They will suffice, however, to illustrate the wide applicability of this means of raising water. If there is any question or uncertainty regarding your special case we shall be glad to correspond with you and arrange for one of our experts personally to examine your property with an idea of advising and furnishing an estimate.

OTHER APPLICATIONS OF THE AIR LIFT

In addition to its value for raising water, compressed air lends itself with especial facility to the difficulties involved in handling brine from salt wells, for raising acids, acid solutions, and other liquids of high specific gravity and corrosive character. In manufacturing establishments it is indispensable for ore leaching, handling dye, paper pulp and fluids. In sugar refineries, or any place where gritty particles and chemical solutions are encountered, and for many other purposes which will suggest themselves, the Air Lift has no equal.

There are no working or moving parts of any sort in contact with the liquid, and in consequence the few pipes and tanks necessary for storage and moving the liquid can be made of materials unaffected by the fluid. Even wooden pipes are sometimes used.

Salt Wells

Brine of a profitable saturation is secured and the output greatly increased. We have equipped many such plants which have not cost a penny since installed, and now operate with perfect satisfaction. We have a special method of piping salt wells developed by a wide experience, which increases the life of the system and avoids difficulties common to this class of well.

One Example

An example of unusual interest is the salt wells of the Messrs. Buckley & Douglass Lumber Company.

These wells are 2,017 feet deep, the last 30 feet of which is solid rock salt. They are cased 8 inches down to 616 feet, the balance being a 7-inch uncased hole. A 4½-inch pipe extends entirely to the bottom of the wells, which provides an annular space around its outside between it and the walls of the wells. Inside of this pipe is a 3-inch liquid discharge pipe extending down 985 feet. At the bottom the outer pipe has a reducer fitted to it, so that if the 3-inch pipe should rust through and drop it would be caught and could be pulled up by the outer pipe.

The fresh water is run down outside of the 4½-inch pipe and kept up to within about 100 feet from the top of the well. It dissolves the rock salt at the bottom, and is lifted up through the central 3-inch pipe, the air being forced down the annular space between the outside of the 3-inch and inside of the 4½-inch pipes.

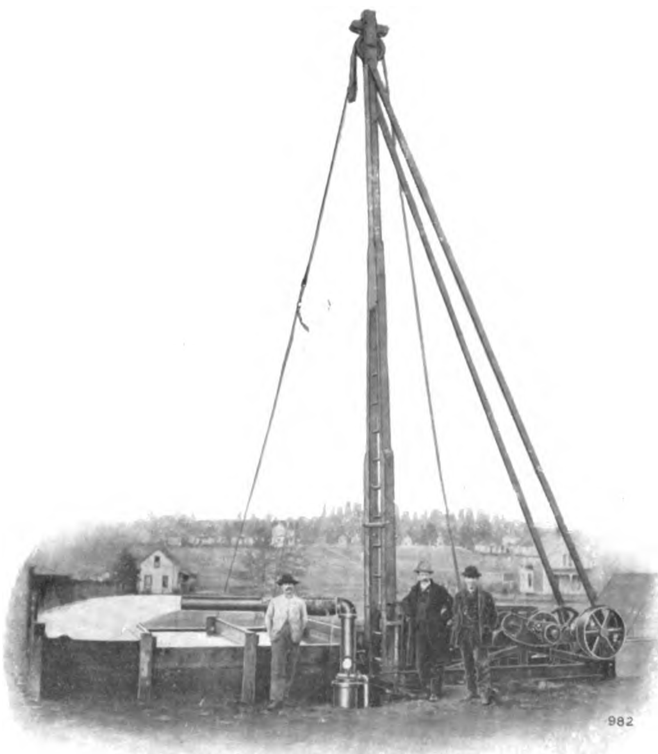
This is practically the arrangement of pipes employed in the Saunders Air Lift system, described on page 31.

The piping was changed to this system because the central air pipe gave a great deal of trouble by corrosion, which attacked not only the air pipe, but the inside of the well casing also, and the air pipe was liable at any time to corrode through and drop.

By changing to the system referred to, the corrosion is confined to the inside of the 3-inch discharge pipe, so they have but one pipe to corrode instead of two. Since this change the trouble has been practically eliminated, and the system has proved most satisfactory and efficient.

The compressor is a straight line Class "AC" Ingersoll-Rand machine, with steam cylinder 22 inches in diameter, and compound air cylinders 18¼ inches and 9 inches, all with a 24-inch stroke.

They pump three wells at a time, and with the compressor running at moderate speed secure about 600 gallons of brine per minute.



Air Lift Plant at Tacoma, Wash., Testing a New Well.

In the foregoing pages applications of the Air Lift pump have been discussed and the limitations of its field of usefulness outlined. But there are other problems in the lifting and handling of water and other liquids, for which the Air Lift does not offer the best solution. Yet, though the method of its application is different, compressed air is still a most useful and economical agent in meeting the peculiar requirements of these situations. The machinery employed in these other operations may be broadly classified under three heads, which will be discussed in order,—displacement pumps, direct-acting piston or plunger pumps, and power-driven pumps.

Displacement Pumps

The displacement pump is almost the essence of pumping simplicity, and, if its first promise were borne out, it would be a most powerful factor in pumping problems. As it is, within its recognized field, it has shown a fitness which qualifies it peculiarly for the work. In its essentials it consists of two barrels, or cylinders, which are filled and discharged alternately, the charge in each cylinder being directly discharged or displaced by the admission of the required volume of compressed air

Quarry of U. S. Silica Co., Ottawa, Ill.
Pumping Sand with Harris Displacement Pump.

through a valve automatically controlled. The fundamental requirement is a complete submergence of 3 to 6 feet. The cylinders are filled at no expenditure of power, discharged with the minimum of friction loss. The pump operates independently of dirt or grit. There is no packing, no leakage. It starts and stops automatically and uses air exactly in proportion to the volume of water discharged. It will run for weeks without attention and requires practically no repairs. Standard sizes have capacities up to 3,000 gallons per minute. The height to which these pumps will lift water is limited only by the air pressure used, and, by an arrangement of several in series, almost any height can be attained with ordinary moderate air pressures.

In mine work, the displacement pump is especially useful in handling the accumulated water in sumps, dips, entries, etc., its requirement of complete submergence being borne in mind. It is also peculiarly effective in subways and tunnels, in automatically discharging the seepage or leakage water which accumulates in a sump. It may also serve in the basements of factories and warehouses which are subject to occasional inundations by floods or high water, its utter disregard of dirt and small debris being of peculiar value in such cases.

The same apparatus, but in a slightly modified form, is employed in manufacturing establishments for elevating acids and heavy chemical solutions, or for pumping marl, paints and other semi-fluids. In these cases the air valve is so located that it is not affected by contact with the liquid, or by corrosive fumes arising from it. The device is also successfully employed in elevating sewage.

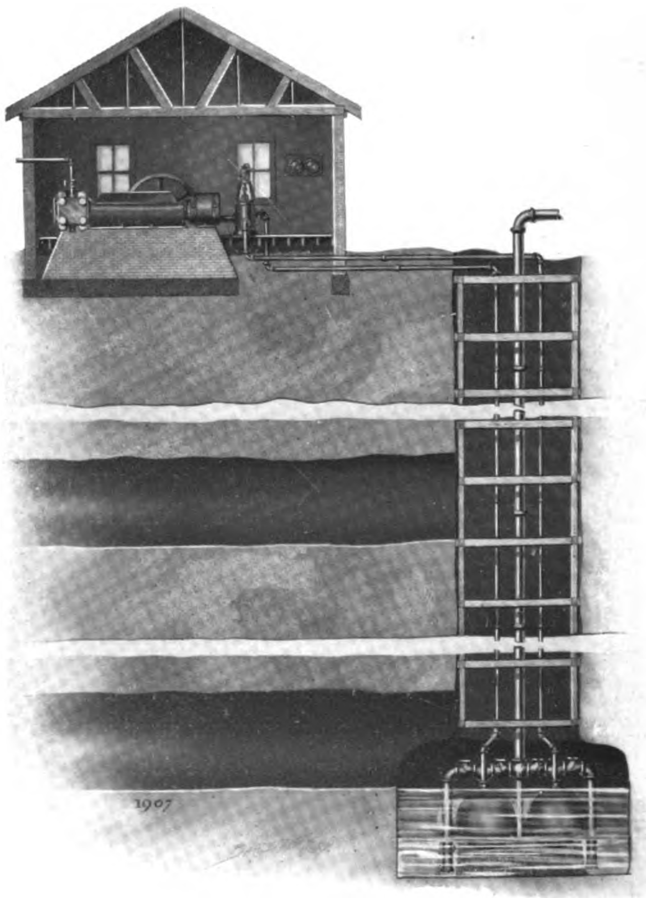
Used alone or in connection with an Air Lift pump, the displacement system is a neat solution of the problem of small water supply. The pump itself is submerged in a pond or reservoir supplied from a natural source, or from artesian wells pumped with the Air Lift. In the latter case, one air plant will supply both Air Lift and pump. Only the simplest machinery is required; attendance becomes a minimum, and the entire system is simple, efficient, almost automatic, and very economical in both first cost and operation.

THE INGERSOLL-RAND "RETURN-AIR" SYSTEM

The Ingersoll-Rand "Return-Air" Pumping System is a modification of, and an improvement upon, the best form of the pneumatic displacement pump. While retaining all the large capacity, simplicity and convenience of the latter, it is free from the two shortcomings which have characterized the simpler type. It may be briefly described as an expansion displacement pump, and its great advantage as compared to the ordinary displacement pump lies in the fact that the potential energy of expansion in the displacing air volume is profitably applied instead of being thrown away.

The Essentials of the System

The 'Return-Air" System is, as implied by its name, not merely a machine, but a complete system in which the air, after doing its work in one tank, returns to the compressor to do some work in the other



A Diagrammatic Illustration of the "Return-Air" System.

tank. The system comprises a closed circuit in which, by a regular cycle of operations, one air volume is compressed, expanded and recompressed and re-expanded indefinitely, each cycle of compression and expansion corresponding with a discharge of one of the pump tanks.

The essentials of the system are an air compressor driven by any convenient motive power; a reversing switch in the compressor room; two air lines; each leading from the compressor through the switch to one pump tank; two tanks submerged in the fluid pumped, or within easy range of siphon action. Provision is of course made for automatically replacing the air which may be lost in the cycle by leakage, absorption or in the operation of the switch.

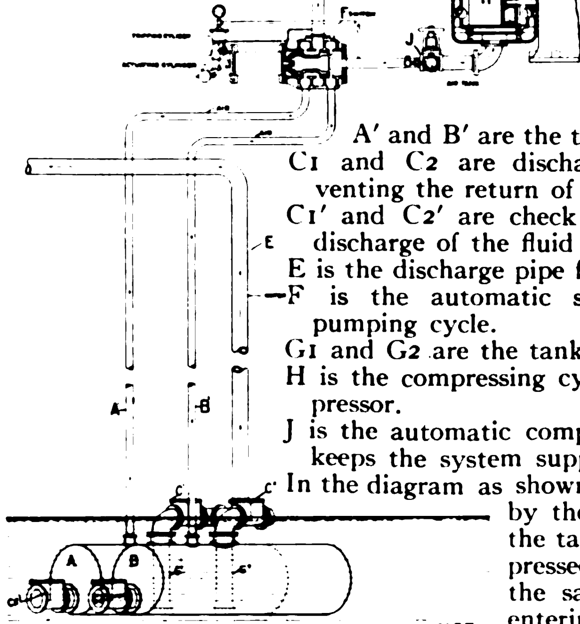
The Principle of Operation

The principle of the "Return-Air" System is very simple. Compressed air is admitted to a tank full of fluid, forcing the fluid out through a suitable discharge pipe, its return being prevented by a check valve. The air which has displaced the fluid from the tank is then expanded back through the air line and switch, through the compressor intake valves, the compressor cylinder and the discharge valves, until equilibrium is secured throughout the system, which then contains a charge

of air at a certain pressure above atmosphere. This equalizing operation takes but a short time during which the compressor operates at no load, pressures being balanced on both sides of its piston. The moment that equilibrium is attained the compressor takes up the load, compressing the air in the second tank and drawing its intake, already at high pressure, from the first tank and pipe line. As pressure increases in the second tank, the fluid is discharged, while as pressure diminishes in the first tank, the fluid enters.

The cycle of operations will be readily understood by following the description on next page in connection with the lettered diagram accompanying.

pletely submerged, though they are operative if so placed as to be filled by siphon action.



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A′ and B′ are the two air pipe lines.

C1 and C2 are discharge check valves preventing the return of the fluid ejected.

C1′ and C2′ are check valves preventing the discharge of the fluid through the inlet.

E is the discharge pipe from both tanks.

F is the automatic switch controlling the pumping cycle.

G1 and G2 are the tank risers.

H is the compressing cylinder of an air compressor.

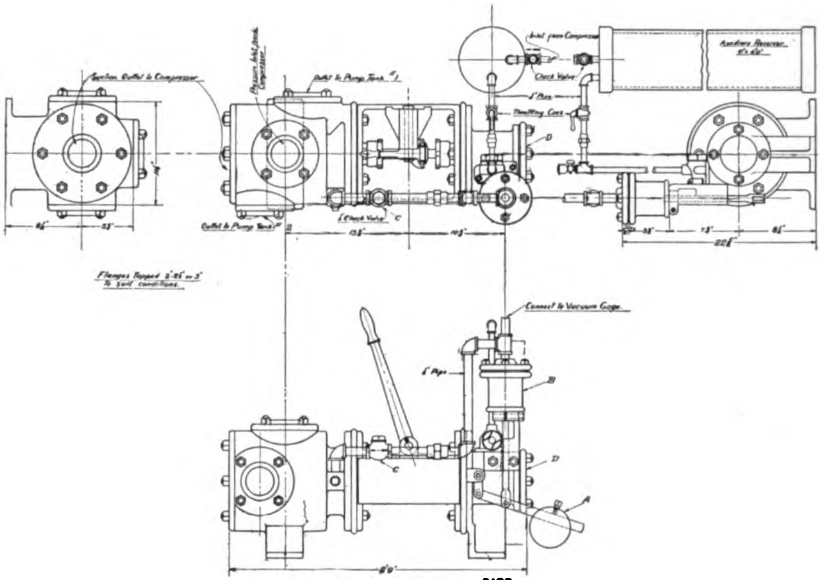
J is the automatic compensating valve which keeps the system supplied with air.

In the diagram as shown air is being withdrawn by the compressor H from the tank B and is being compressed in the tank A. At the same time the fluid is entering the tank B through the check valve C2′, while it is being forced from the tank A through the riser G1, the check valve C′ and the discharge pipe E.

Arrangements are such that when the tank B is completely filled the switch F automatically reverses, exactly reversing the condition of affairs. The air at full pressure in the tank A expands through the switch F and cylinder H into the pipe line B′ until equilibrium is recovered at a higher pressure, at which time the compressor takes up the load, forcing air from the tank A through the switch F into the pipe B′ and the tank B, displacing the fluid in the latter. The moment the pressure in the tank A is expanded to a point where it is lower than the hydraulic head, the fluid will enter this tank through C1′ until the tank A is filled. At this point the switch F will again automatically reverse, reversing the conditions for another cycle.

The second type of switch is known as the mechanical switch. It is arranged to automatically reverse when the compressor has made a certain number of strokes, this number being determined beforehand, as that necessary to completely discharge one tank.

The question as to which of these switches will be used in a given case depends upon the local problems, and the Company will install the one which best meets the demands of the situation.



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The Automatic Switch

Two types of governor switch can be furnished with this system, depending upon local conditions.

The first type is simply an air operated piston valve similar to that used on steam engines and rock drills. Each throw of the valve corresponds with the filling of one tank. A valve is thrown by atmospheric pressure on one end, overcoming a partial vacuum at the other end, this difference of pressures being secured in the following manner. This system is so installed that normally the tanks are filled with water by gravity; thus the water comes into the tank as the air goes out, without any "suction" action by the latter. In other words, when a tank is level full of water the air pressure in the pipe from that tank is normally at atmosphere. But as the compressor continues to withdraw air from this pipe a slight vacuum is created. The reversing switch is connected to this pipe, and this partial vacuum on one end of the auxiliary valve is overcome by full atmospheric pressure on the other end, throwing the auxiliary valve, which in turn throws the main valve. A recurrence of this phenomenon on the filling of the second tank throws the switch back for another cycle. Where circumstances are such that the tanks must be filled by a siphon action, the switch is adjusted so that it throws only when a higher vacuum is reached, thus providing for the additional lift on the intake.

Compensation for Leakage

There will be a continuous though very small loss of air from the system, due to the air used in the operation of the switch when the latter is of the first type. Leakage and absorption in the water will also consume a small quantity of air. These losses are automatically supplied by the compensating valve J, which is simply an atmospheric check valve opening when a partial vacuum is created on its inner face. This occurs at the point in the cycle where pressure drops below the permissible vacuum, thus indicating that the charge in the system is insufficient. A globe valve outside the valve J may be adjusted to admit just the right amount of air to maintain operative conditions.

Starting the System

When starting the "Return-Air" System it operates during the first cycle as a plain displacement pump, the compressor taking its intake at atmosphere through the valve J and its associated globe valve, which is opened full for this purpose. As soon as the required pressure is secured in the system the check valve automatically closes and the regular cycle of compression and expansion begins, the outer globe valve being then adjusted as noted in the previous section.

Efficiency

Under normal conditions the system will show an average efficiency of 55 per cent. Some installations have returned as high as 60 per cent., and never, even under unfavorable conditions, has less than 40 per cent. been shown. These figures represent the actual ratio of horse power of water lifted to the I. H. P. of the compressor steam cylinder, with all losses included. It is not difficult, with these percentages as a basis, to figure the actual power cost in a given case, where all the local conditions are definitely known, such as the price per ton of coal and the cost of boiler feed water. Yet fuel economy is but one argument in favor of the "Return-Air" System.

For Pumping Semi-Fluids

It is applicable to the pumping of all fluids and semi-fluids, on account of these characteristics. It is simple in construction, installation and management, requiring only attendance of the average engineer. Once in operation it is entirely automatic; yet it is under instant and complete control from the compressor room, however distant. There are no stuffing boxes, glands, pistons, or plungers in contact with the fluid, and no delicate mechanism exposed to corrosive or abrasive action. No oil or other lubricant is required at the pump. Excess submergence only improves the economy.

These facts adapt the system for the handling of solutions, as in salt works, bleacheries, tanneries, etc.; the moving of semi-fluids, as in pulp mills; handling cement slurry and marl; pumping glass sand for glass factories; and the elevation of sewage.

Direct-Acting Piston or Plunger Pumps

The direct-acting piston pump, of simple or duplex type, has a most unenviable reputation as a "steam-eater." It is one of the most uneconomical devices known. Generally speaking, the simple pump is a little more economical than the duplex, but even the pump builder figures at 150 pounds of steam per horse power hour in his pumps. Some claim only 125 pounds. Others, in strictest confidence, will confess to from 175 to 250 pounds. The facts are elusive, but the first figure is a happy medium, and will serve the purpose in emphasizing the utterly wasteful character of the direct-acting pump, especially when it is remembered that the ordinary automatic steam engine, itself no miser of steam, requires 30 to 35 pounds of steam per horse power hour. Experiments have shown that under average conditions hardly 50 per cent. of the indicated horse power of the driving cylinder is utilized in the pump cylinder, the rest being absorbed partly by the engine as machine friction, but principally by the friction of the water in passage through valves and chambers.

From these facts it follows that when it is attempted to apply compressed air in place of steam to direct-acting piston pumps, the result is likely to be a system of air-consumers painful to the manager and ruinous in the reduction of profit. But if electricity were to be adopted in place of steam as a motive agent, the engineer who attempted to apply an electric motor to an old piston pump would do so at a most serious risk to his reputation as a man of sense as well as an engineer. He would more likely replace the old "steam-eaters" by high grade duplex or triplex power pumps, geared to motors and operating at high efficiency. Yet it is a piece of folly as rank as that already cited to apply compressed air, with any hope of economy, to a badly cut and worn steam pump, with driving cylinders probably incorrectly proportioned to the work, and a clearance out of all reason. If the same care and skill is exercised in applying compressed air as in adapting electric power, a pneumatic engineer being retained to select proper compressed air pumps and lay out a correct distribution system, compressed air as a power for pumps will be in much better repute. For the electric pump is characterized by high first cost, frequent attention, liability to short-circuits and burn-outs in damp locations, expensive maintenance, and annoying loss of time in repairs. Even a properly designed air-driven direct-acting pump may not show such intrinsic high net efficiency, but the compressed air system cannot be drowned out and lends itself more readily than the electric to the securing of economical results; and *results* are most important and desirable things. In a compressed air pumping system, with power properly produced, delivered and applied, there is no question whatever as to the saving in net horse power from coal-bin to pump.

The subject of pumping with air-driven, direct-acting pumps is a vast and important one, which, be it here confessed, has been sadly neglected not only by engineers in general, but by the manufacturers of air machinery themselves. It is worthy of closest study, and it is encouraging to note that it is to-day receiving the attention it deserves. Where compressed air is to be used for pumping exclusively, several methods of satisfactorily meeting the conditions are available, the merits of each one to be carefully weighed in the scale of local conditions.

One of the simplest and most efficient of these methods is that known as the "dense air" or "closed circuit" system. In this the same air is used over and over again, the exhaust from the pumps being piped back to the compressor under a limited back pressure. The compressed air is a transmitter of power pure and simple, just as is a belt or transmission rope. But the medium never wears out, can be carried to any distance and at all angles, has no inherent friction, and enjoys the highest transmission efficiency. The system eliminates all trouble from freezing, since the air is used repeatedly and moisture once removed cannot be returned. The pump cylinders will be smaller because of the higher M. E. P., and the losses in clearance, often enormous, are entirely eliminated. But the greatest economy is secured in compression, the system being based upon the well-known fact that the greatest losses in compression occur at the lower pressures.

For instance, 8.46 H. P. are required to compress 100 cubic feet of free air from atmosphere to 30 pounds pressure. But if the initial pressure was 30 pounds the same amount of power would produce a pressure of 90 pounds. Now suppose this air at 90 pounds was applied to a pump exhausting at 30 pounds, the exhaust being piped back to the compressor, where the exhaust pressure became the initial pressure of compression. The available effective pressure at the pump would thus be 90 minus 30, or 60 pounds, and the power required in compression would be 8.46 H. P. On the other hand, suppose 100 cubic feet of free air was delivered to the pump at 60 pounds pressure, exhausting at atmosphere. This would give the same available, effective pressure at the pump and the same volume of free air, but it would be secured at the expenditure of 13.42 H.P. The return pipe system, therefore, of which the first instance is an example, in this case secures a saving in compression alone of 4.96 H. P.

Take an example of the working of the principle at higher pressures: 13.42 H. P. will compress 100 cubic feet of free air to 60 pounds pressure, starting at atmosphere. Starting with this air at 60 pounds the same power will compress it to 350 pounds, giving on the return pipe system 290 pounds available pressure with 60 pounds back pressure, all with the

same amount of power required to secure 60 pounds available pressure with the open system. These examples illustrate the principle and possibilities of the closed pipe system. A reheater at the pump will secure additional economy. Losses through leakage in transmission will be supplied by a small "booster" compressor. Or where a limited amount of air is used from the system for purposes other than pumping, it will be withdrawn from the low pressure pipe and exhausted direct, the "booster" in this case being increased in capacity to supply this volume withdrawn from the circuit.

In Conclusion

In conclusion be it said that the subject of pumping with compressed air is a very broad one, requiring the combination of the best engineering skill with sound practical experience. The pages preceding have shown some of its possibilities and made clear the fact that extreme economy need not be neglected. Water can be pumped by compressed air with good results and high economy, and this in places where steam is forbidden and electricity, even at its best, would be very much at a disadvantage.

In every case full information as to conditions should be placed in the hands of the machine builder, who will then be able to properly advise. The Ingersoll-Rand Company, therefore, subjoins the list following as a guide. Upon receipt of the information tabulated, they will advise in full.

1. Total vertical lift between water levels.
2. Total horizontal distance.
3. Rise and fall of water level.
4. All cylinder dimension of pumps now in use.
5. Diameter and length, and number of elbows, in water pipe leading from pump to point of discharge.
6. Diameter, length and vertical height of suction pipe.
7. Amount of water required per minute, in gallons.
8. Hours per day plant is to run.
9. Horse power of boilers now required to run pumps.
10. Steam pressure on present boilers.
11. Purpose for which water is used.
12. Amount of coal per hour at present burned to run pumps.
13. Distance from proposed compressor to pump.
14. Character of water as to acids, grit, debris, etc.
15. Cost of fuel.

Air Mains, Initial and Final Pressures

45 Pounds Initial Gauge Pressure.

Diameter of Pipe Inches	Reduction of Final Pressure in 500 Feet						
	1 Pound	2 Pounds	3 Pounds	5 Pounds	7 Pounds	9 Pounds	12 Pounds
1	14	20	24	30	34	37	40
1¼	26	36	44	54	62	68	74
1½	43	60	72	90	102	112	121
2	95	132	159	198	226	247	268
2½	172	239	287	358	409	446	484
3	281	390	470	585	667	728	791
3½	419	583	701	874	997	1080	1180
4	595	827	995	1240	1410	1540	1670
4½	806	1120	1340	1680	1910	2090	2270
5	1050	1470	1770	2200	2510	2740	2980
6	1690	2350	2820	3520	4020	4380	4760
7	2500	3480	4190	5220	5950	6500	7060
8	3520	4900	5890	7340	8370	9140	9930
9	4770	6630	7970	9930	11300	12300	13400
10	6240	8680	10400	13000	14800	16100	17600

60 Pounds Initial Gauge Pressure.

Diameter of Pipe Inches	1 Pound	2 Pounds	3 Pounds	5 Pounds	7 Pounds	9 Pounds	12 Pounds
1	16	22	27	34	39	43	48
1¼	29	41	49	62	72	79	87
1½	48	67	81	102	117	129	143
2	107	149	180	226	259	286	315
2½	193	269	325	408	469	516	569
3	315	440	532	667	766	844	930
3½	471	657	794	996	1140	1260	1380
4	668	932	1120	1410	1620	1780	1970
4½	905	1260	1520	1910	2190	2420	2660
5	1180	1650	2000	2510	2880	3170	3500
6	1890	2650	3200	4010	4610	5080	5590
7	2810	3920	4740	5950	6840	7530	8290
8	3960	5520	6670	8370	9620	10500	11600
9	5350	7470	9020	11300	13000	14300	15700
10	7010	8710	11800	14800	17000	18700	20700

75 Pounds Initial Gauge Pressure.

Diameter of Pipes Inches	Reduction of Final Pressure in 500 Feet						
	1 Pound	2 Pounds	3 Pounds	5 Pounds	7 Pounds	9 Pounds	12 Pounds
1	18	25	30	38	44	48	54
1¼	32	45	55	69	80	89	98
1½	53	74	90	13	131	145	161
2	117	164	199	251	289	320	356
2½	212	296	359	453	523	579	643
3	346	484	587	740	855	946	1050
3½	517	723	876	1100	1270	1410	1560
4	734	1020	1240	1560	1810	2000	2220
4½	994	1390	1680	2120	2450	2710	3010
5	1300	1820	2210	2780	3220	3560	3950
6	2080	2910	3530	4450	5140	5690	6320
7	3090	4320	5230	6600	7630	8440	9370
8	4350	6070	7360	9290	10700	11800	13100
9	5880	8220	9960	12500	14500	16000	17800
10	7710	10700	13000	16400	19000	21000	23300

90 Pounds Initial Gauge Pressure.

Diameter of Pipes Inches	1 Pound	2 Pounds	3 Pounds	5 Pounds	7 Pounds	9 Pounds	12 Pounds
1	19	27	33	41	48	53	60
1¼	35	49	59	75	87	97	109
1½	57	80	97	123	143	159	178
2	127	178	215	273	316	351	394
2½	229	321	390	493	572	635	712
3	375	525	636	806	934	1030	1160
3½	560	784	950	1200	1390	1550	1730
4	794	1110	1340	1700	1980	2190	2460
4½	1070	1500	1820	2310	2680	2970	3330
5	1410	1970	2390	3030	3510	3900	4370
6	2250	3160	3830	4850	5620	6240	6990
7	3340	4680	5680	7190	8340	9260	10300
8	4700	6590	7990	10100	11700	13000	14500
9	6360	8930	10800	13600	15800	17600	19700
10	8340	11600	14100	17900	20700	23000	25800

Air Mains, Initial and Final Pressures

Initial Gauge Pressure, 105 Pounds

Diam. Pipe	Reduction of Final Pressure in 500 Feet.						
	1 lb.	2 lbs.	3 lbs.	5 lbs.	7 lbs.	9 lbs.	12 lbs.
1 in..	20	29	37	44	52	58	65
1¼ " ..	37	52	68	81	94	105	118
1½ " ..	61	86	111	133	155	172	194
2 " ..	129	190	245	294	341	380	427
2½ " ..	245	344	443	531	617	687	772
3 " ..	401	562	724	867	1,000	1,120	1,260
3½ " ..	599	839	1,080	1,290	1,500	1,670	1,880
4 " ..	850	1,190	1,530	1,830	2,130	2,370	2,670
4½ " ..	1,150	1,610	2,070	2,480	2,890	3,220	3,610
5 " ..	1,510	2,110	2,720	3,260	3,790	4,220	4,750
6 " ..	2,410	3,380	4,350	5,220	6,070	6,760	7,590
7 " ..	3,580	5,010	6,460	7,740	8,990	10,000	11,200
8 " ..	5,030	7,050	9,080	10,800	12,600	14,000	15,800
9 " ..	6,810	9,540	12,200	14,700	17,100	19,000	21,400
10 " ..	8,920	12,500	16,100	19,200	22,400	24,900	28,000

EXAMPLE

It is required to deliver 2,000 cubic feet of equivalent free air at the end of a pipe line 1,500 feet long, the initial pressure being 60 pounds, and the loss of pressure not to exceed 10 pounds; what diameter of pipe must be used?

By table of 60 pounds initial pressure under 3 pounds loss, and oppcsite 5 inch diameter of pipe, we see that the delivery would be 2,000 cubic feet, so that for a pipe line 1,500 feet long, the loss of pressure would be about 3×1,500÷500=9 pounds. We say "about" 9 pounds, because the loss is not exactly proportional to the length, but nearly so when the basis of length is 5 00 feet.

Globe Valves, Tees and Elbows

The reduction of pressure produced by globe valves is the same as that caused by the following additional lengths of straight pipe, as calculated by the formula:

$$\text{Additional length of pipe} = \frac{114 \times \text{diameter of pipe}}{1 + (3.6 \text{ M diameter})}$$

Diameter of pipe	1	1½	2	2½	3	3½	4	5	6 inches
Additional length	2	4	7	10	13	16	20	28	36 feet
	7	8	10	12	15	18	20	22	24 inches
	44	53	70	88	115	143	162	181	200 feet

The reduction of pressure produced by elbows and tees is equal to two-thirds of that caused by globe valves. The following are the additional lengths of straight pipe to be taken into account for elbows and tees. For globe valves multiply by $\frac{3}{2}$:

Diameter of pipe	1	1½	2	2½	3	3½	4	5	6 inches
Additional length	2	3	5	7	9	11	13	19	24 feet
	7	8	10	12	15	18	20	22	24 inches
	30	35	47	59	77	96	108	120	134 feet

These additional lengths of pipe for globe valves, elbows and tees must be added in each case to the actual lengths of straight pipe. Thus a 6-inch pipe, 500 feet long, with 1 globe valve, 2 elbows and 3 tees, would be equivalent to a straight pipe 500 + 36 + (2 × 24) + (3 × 24) = 656 feet long.

Table of Standard Dimensions of Wrought Iron Pipe

Nominal Inside Diameter.	Actual Inside Diameter.	Actual Outside Diameter.	Internal Area Square Inches.	External Area Square Inches.	U. S. Gallon per Foot of Pipe.	Weight of Pipe per Lineal Foot.
Inches.	Inches.	Inches.	Sq. Inches.	Sq. Inches.	Gallons	Pounds
⅛	.270	.405	.057	.1288	.0029	.24
¼	.364	.540	.104	.2290	.0054	.42
⅜	.493	.675	.191	.3578	.0099	.56
½	.622	.840	.304	.554	.0158	.84
¾	.824	1.050	.533	.866	.0277	1.12
1	1.048	1.315	.861	1.358	.0447	1.67
1¼	1.380	1.660	1.496	2.164	.0777	2.24
1½	1.610	1.900	2.036	2.835	.1058	2.68
2	2.067	2.375	3.356	4.430	.1743	3.61
2½	2.468	2.875	4.780	6.492	.2483	5.74
3	3.067	3.500	7.383	9.621	.3835	7.54
3½	3.548	4.000	9.887	12.566	.5136	9.00
4	4.026	4.500	12.730	15.904	.6613	10.66
4½	4.508	5.000	15.961	19.635	.829	12.34
5	5.045	5.563	19.986	24.301	1.038	14.50
6	6.065	6.625	28.890	34.472	1.500	18.76
7	7.023	7.625	38.738	45.664	2.012	23.27
8	7.981	8.625	50.027	58.426	2.599	28.18
9	8.927	9.635	62.730	72.760	3.259	33.70
10	10.018	10.75	78.823	90.763	4.095	40.06
11	11.000	11.75	95.033	108.434	4.937	45.02
12	12.000	12.75	113.098	127.677	5.875	49.00
13	13.25	14	137.887	153.938	7.163	54.00
14	14.25	15	159.485	176.715	8.285	58.00
15	15.25	16	182.665	201.062	9.489	62.00

Standard Dimensions of Couplings for Steam, Gas and Water Pipe—Black and Galvanized

Size of Pipe, Nominal, Inside Diameter.	Inside Diameter of Coupling.	Outside Diameter of Coupling.	Outside Area of Coupling.	Length of Coupling.	Threads per Inch of Screw.	Average Weight of Coupling in Pounds.
Inches.	Inches.	Inches.	Sq. Inches.	Inches.		
⅛	11-32	19-32	.276	13-16	27	.031
¼	15-32	23-32	.405	15-16	18	.046
⅜	37-64	27-32	.559	1 1-16	18	.078
½	23-32	1	.785	1 5-16	14	.124
¾	63-64	1 21-64	1.382	1 9-16	14	.250
1	1 11-64	1 9-16	1.917	1 13-16	11½	.455
1¼	1½	1 61-64	2.953	2⅛	11½	.562
1½	1¾	2 7-32	3.832	2⅜	11½	.800
2	2 7-32	2¾	5.939	2⅝	11½	1.250
2½	2 21-32	3 9-32	8.419	2⅞	8	1.757
3	3¼	3 15-16	12.177	3⅛	8	2.625
3½	3 25-32	4 7-16	15.466	3⅜	8	4.000
4	4 17-64	5	19.635	3⅝	8	4.125
4½	4¾	5½	23.758	3⅝	8	4.875
5	5 9-32	6 7-32	30.347	4⅛	8	8.437
6	6 11-32	7 5-16	41.991	4⅛	8	10.625
7	7⅜	8 5-16	54.255	4⅛	8	11.270
8	8⅜	9 5-16	68.078	4⅝	8	15.150
9	9 7-16	10⅜	84.541	5⅛	8	17.820
10	10 7-16	11 21-32	106.688	6⅛	8	27.700
11	11 15-32	12 21-32	125.78	6⅛	8	33.250
12	12 7-16	13⅞	151.20	6⅛	8	43.187
13	13 11-16	15 1-16	178.16	6⅛	8	49.280
14	14 23-32	16⅜	210.60	6⅛	8	63.270
15	15 11-16	17⅜	237.10	6⅛	8	66.000

MEAN EFFECTIVE PRESSURE AND HORSE-POWER

DEVELOPED IN COMPRESSING A CUBIC FOOT OF AIR

(ADIABATICALLY)

FROM ATMOSPHERIC PRESSURE (14.7 lbs.) TO VARIOUS GAUGE PRESSURES

INITIAL TEMPERATURE OF AIR IN EACH CYLINDER TAKEN AS 60° Fh.
JACKET COOLING NOT CONSIDERED

Gauge Pressure—Pounds	Absolute Pressure—Pounds	Number of Atmospheres Compressed	Single Compression				Two-stage Compression				Per cent. of Power Saved by Two-stage over Single Compression (Theoretical)
			M. E. P. per Square Inch (Theoretical)	Developed Horse-power (Theoretical)	M. E. P. per Square Inch 15% Friction Included	Developed Horse-power 15% Friction Included	M. E. P. per Sq. Inch Reduced to Low-pressure Air Cylinder (Theoretical)	Developed Horse-power (Theoretical)	M. E. P. per Sq. Inch Reduced to Low-pressure Air Cylinder 15% Friction Included	Developed Horse-power 15% Friction Included	
5	19.7	1.34	4.46	.019	5.12	.022	.....	....	.....	....	....
10	24.7	1.68	8.21	.036	9.44	.041	.....	....	.....	....	....
15	29.7	2.02	11.46	.050	13.17	.057	.....	....	.....	....	....
20	34.7	2.36	14.30	.062	16.44	.071	.....	....	.....	....	....
25	39.7	2.70	16.94	.074	19.47	.085	.....	....	.....	....	....
30	44.7	3.04	19.32	.084	22.21	.096	.....	....	.....	....	....
35	49.7	3.38	21.50	.094	24.72	.108	.....	....	.....	....	....
40	54.7	3.72	23.53	.103	27.05	.118	.....	....	.....	....	....
45	59.7	4.06	25.40	.111	29.21	.127	.....	....	.....	....	....
50	64.7	4.40	27.23	.119	31.31	.136	.....	....	.....	....	....
55	69.7	4.74	28.90	.126	33.23	.145	.....	....	.....	....	....
60	74.7	5.08	30.53	.133	35.10	.153	.....	....	.....	....	....
65	79.7	5.42	32.10	.140	36.91	.161	.....	....	.....	....	....
70	84.7	5.76	33.57	.146	38.59	.168	29.31	.128	33.71	.147	12.7
75	89.7	6.10	35.00	.153	40.25	.175	30.43	.133	34.99	.153	13.0
80	94.7	6.44	36.36	.159	41.80	.182	31.44	.137	36.15	.158	13.5
85	99.7	6.78	37.63	.164	43.27	.189	32.46	.142	37.32	.163	13.8
90	104.7	7.12	38.89	.169	44.71	.195	33.37	.145	38.36	.167	14.2
95	109.7	7.46	40.11	.175	46.12	.201	34.28	.149	39.41	.172	14.5
100	114.7	7.80	41.28	.180	47.46	.207	35.20	.153	40.48	.176	14.7
110	124.7	8.48	43.56	.190	50.09	.218	36.82	.161	42.34	.185	15.4
120	134.7	9.16	45.69	.199	52.53	.229	38.44	.168	44.20	.193	15.9
130	144.7	9.84	47.72	.208	54.87	.239	39.86	.174	45.83	.200	16.5
140	154.7	10.52	49.64	.216	57.08	.249	41.28	.180	47.46	.207	16.9
150	164.7	11.20	51.47	.224	59.18	.258	42.60	.186	48.99	.214	17.2
160	174.7	11.88	.....	....	.....	....	43.82	.191	50.39	.219	....
170	184.7	12.56	.....	....	.....	....	44.93	.196	51.66	.225	....
180	194.7	13.24	.....	....	.....	....	46.05	.201	52.95	.231	....
190	204.7	13.92	.....	....	.....	....	47.16	.206	54.22	.236	....
200	214.7	14.60	.....	....	.....	....	48.18	.210	55.39	.241	....
250	264.7	18.00	.....	....	.....	....	52.84	.230	60.76	.264	....
300	314.7	21.40	.....	....	.....	....	56.70	.247	65.20	.283	....
350	364.7	24.81	.....	....	.....	....	60.15	.262	69.16	.301	....
400	414.7	28.21	.....	....	.....	....	63.19	.276	72.65	.317	....
450	464.7	31.61	.....	....	.....	....	65.93	.287	75.81	.329	....
500	514.7	35.01	.....	....	.....	....	68.46	.298	78.72	.342	....
550	564.7	38.41	.....	....	.....	....	70.70	.308	81.30	.354	....
600	614.7	41.81	.....	....	.....	....	72.83	.317	83.75	.364	....

Contents in Cubic Feet and U. S. Gallons of Cylinders of Various Diameters and One Foot in Length

For 1 Foot in Length.			For 1 Foot in Length.			For 1 Foot in Length.		
Diameter in Inches.	Cubic Feet; also Area in Square Feet.	U. S. Gallons, 231 Cubic Inches.	Diameter in Inches.	Cubic Feet; also Area in Square Feet.	U. S. Gallons, 231 Cubic Inches.	Diameter in Inches.	Cubic Feet; also Area in Square Feet.	U. S. Gallons 231 Cubic Inches.
1	.055	.0408	11¾	.7530	5.633	42	9.621	71.97
1¼	.0085	.0638	12	.7854	5.875	43	10.085	75.44
1½	.0123	.0918	12½	.8522	6.375	44	10.559	78.99
1¾	.0167	.1249	13	.9218	6.895	45	11.045	82.62
2	.0218	.1632	13½	.994	7.436	46	11.541	86.33
2¼	.0276	.2066	14	.069	7.997	47	12.048	90.13
2½	.0341	.2550	14½	1.147	8.578	48	12.566	94.00
2¾	.0412	.3085	15	1.227	9.180			
3	.0491	.3672	15½	1.310	9.801			
3¼	.0576	.4309	16	1.396	10.44			
3½	.0668	.4998	16½	1.485	11.11			
3¾	.0767	.5738	17	1.576	11.79			
4	.0873	.6528	17½	1.670	12.49			
4¼	.0985	.7369	18	1.768	13.22			
4½	.1134	.8263	18½	1.867	13.96			
4¾	.1231	.9206	19	1.969	14.73			
5	.1364	1.020	19½	2.074	15.51			
5¼	.1503	1.125	20	2.182	16.32			
5½	.1650	1.234	20½	2.292	17.15			
5¾	.1803	1.349	21	2.405	17.99			
6	.1963	1.469	21½	2.521	18.86			
6¼	.2131	1.594	22	2.640	19.75			
6½	.2304	1.724	22½	2.761	20.66			
6¾	.2485	1.859	23	2.885	21.58			
7	.2673	1.999	23½	3.012	22.53			
7¼	.2867	2.145	24	3.142	23.50			
7½	.3068	2.295	25	3.409	25.50			
7¾	.3276	2.45	26	3.687	27.58			
8	.3491	2.611	27	3.976	29.74			
8¼	.3712	2.777	28	4.276	31.99			
8½	.3941	2.948	29	4.587	34.31			
8¾	.4176	3.125	30	4.909	36.72			
9	.4418	3.305	31	5.241	39.21			
9¼	.4667	3.491	32	5.585	41.78			
9½	.4922	3.682	33	5.940	44.43			
9¾	.5185	3.879	34	6.305	47.16			
10	.5454	4.08	35	6.681	49.98			
10¼	.5730	4.286	36	7.069	52.88			
10½	.6013	4.498	37	7.467	55.86			
10¾	.6303	4.715	38	7.876	58.92			
11	.66	4.937	39	8.296	62.06			
11¼	.6903	5.164	40	8.727	65.28			
11½	.7213	5.396	41	9.168	68.58			

Friction of Water in Pipes

Pressure in Pounds per Square Inch to be added for each 100 Feet of Clean Pipe

Gallons per Min. Delivered	Pipe Sizes.											
	2	2½	3	3½	4	5	6	7	8	9	10	12
5	.04	.02										
10	.12	.04	.02									
15	.25	.08	.04	.02								
20	.42	.14	.06	.03								
25	.62	.21	.10	.04	.02							
30	.91	.30	.13	.06	.03							
35	1.22	.40	.17	.09	.05	.02						
40	1.60	.53	.23	.11	.06	.02						
45	1.99	.66	.28	.14	.07	.03						
50	2.44	.81	.35	.17	.09	.04						
60	3.50	1.17	.50	.24	.13	.05	.02					
70	4.80	1.50	.60	.38	.19	.07	.03					
75	5.32	1.80	.74									
80	6.30	2.00	.90	.41	.23	.08	.03					
90	7.80	2.58	1.10	.54	.26	.09	.04					
100	9.46	3.20	1.31	.64	.33	.12	.05	.02				
125	14.9	4.89	1.99	.96	.49	.17	.07	.03				
150	21.2	7.00	2.85	1.35	.69	.25	.10	.04				
175	28.1	9.46	3.85	1.82	.93	.34	.13	.05				
200	37.5	12.47	5.02	2.38	1.22	.42	.17	.07				
250		19.66	7.76	3.70	1.89	.65	.26	.12	.07	.04	.03	.01
300		28.06	11.2	5.04	2.66	.93	.37	.17	.09	.05	.04	
350			15.2	7.10	3.65	1.26	.50	.23	.12	.07	.05	.02
400			19.5	9.25	4.73	1.61	.65	.30	.16	.09	.06	
450			25.0	11.70	6.01	2.00	.81	.37	.20	.11	.07	.03
500			30.8	14.5	7.43	2.40	.96	.45	.25	.14	.09	.04
750							2.21	1.03	.53	.30	.18	.08
1000							3.88	1.80	.94	.53	.32	.13
1250							6.00	2.85	1.46	.82	.49	.20
1500							8.60	4.08	2.09	1.17	.70	.29

Table is based on Ellis' and Howland's Experiments. To find "Friction Head" in feet multiply figures by 2.3.

Friction of Water in Elbows

Pressure in Pounds per Square Inch to be added for each Elbow

Gallons per Min. Delivered	Pipe Sizes.											
	2	2½	3	3½	4	5	6	7	8	9	10	12
5	.002											
10	.006	.003										
15	.014	.005										
20	.025	.012	.005									
25	.038	.02	.008									
30	.055	.028	.011									
35	.076	.037	.015	.009								
40	.098	.049	.02	.011	.007							
45	.125	.062	.026	.015	.009							
50	.153	.08	.032	.017	.01							
60	.22	.112	.044	.026	.015	.006	.003					
70	.304	.148	.06	.035	.021	.009	.004	.002				
75	.35	.172	.072	.04	.024	.01	.005	.003				
80	.392	.196	.08	.044	.027	.012	.005	.003				
90	.50	.248	.104	.06	.035	.014	.007	.004				
100	.612	.32	.128	.068	.043	.017	.008	.005	.003	.002		
125	.970	.48	.20	.112	.067	.027	.013	.007	.004	.003	.002	
150	1.39	.685	.286	.16	.096	.039	.019	.01	.006	.004	.003	.001
175	1.90	.935	.390	.218	.132	.053	.026	.014	.009	.005	.004	.002
200	2.44	.128	.512	.272	.172	.068	.032	.02	.011	.007	.005	.002
250	3.86	1.91	.80	.446	.268	.109	.025	.029	.017	.011	.007	.004
300	5.56	2.74	1.14	.64	.384	.156	.076	.042	.025	.016	.01	.005
350		3.77	1.58	.88	.530	.215	.103	.057	.034	.022	.014	.007
400		5.12	2.05	1.09	.688	.272	.128	.08	.044	.028	.018	.009
450		6.20	2.58	1.45	.870	.352	.170	.094	.057	.036	.023	.011
500		7.64	3.20	1.78	1.07	.436	.208	.116	.068	.044	.028	.016
750					2.42	.970	.470	.260	.156	.10	.063	.031
1000					4.28	1.74	.832	.464	.272	.176	.112	.064
1250					6.70	2.71	1.31	.728	.435	.276	.175	.086
1500					9.68	3.88	1.88	.84	.624	.40	.252	.124

Table is based on Weisbach's formula for very short bends, or with a radius equal to the radius of the pipe. To find "Friction Head" in feet multiply figures by 2.3.

RULES FOR CALCULATING PUMPS

Rule 1

To find the capacity of a double-acting pump: square the diameter of the water cylinder and for a single cylinder pump, multiply by 4; for a duplex pump multiply by 8; for a triplex pump multiply by 12; and for a quadruplex pump multiply by 16. This gives the discharge in gallons per minute at piston speed of 100 feet. For piston speed other than 100 feet, multiply the result secured as above by the ratio of the given speed to 100. Thus for speed of 80 feet, multiply by 8.

Rule 2

To find the diameter of a double-acting pump to discharge the given volume of water: for single cylinder pumps divide the discharge in gallons by 4; for duplex pumps by 8; for triplex by 12; and for quadruplex by 16.

Extract the square root of the result so secured, giving the diameter in inches of the water cylinder of the pump which at 100 feet piston speed will deliver the required volume.

For piston speed other than 100 feet divide the discharge by the ratio of the given piston speed to 100 and proceed as above.

Rule 3

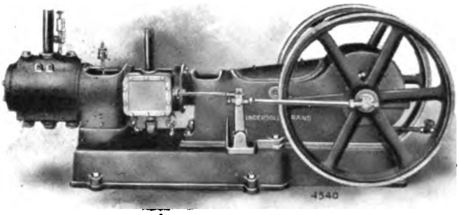
To find the size of a pump to feed a given boiler: multiply the boiler horse power by 6 and divide the result by 100. This gives the required discharge of the pump in gallons per minute, and the size of the pump may then be found by Rule 2. *Boiler feed pumps should not run at a piston speed of more than* 30 *to* 50 *feet.*

Note

The results secured by these rules are not exact but are sufficiently close for all practical purposes.

Standard Steam Driven Types

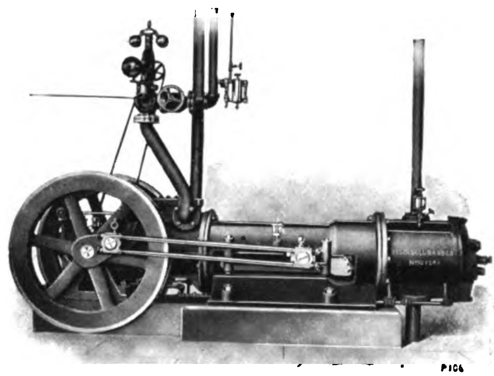
Ingersoll Class "NF-1"



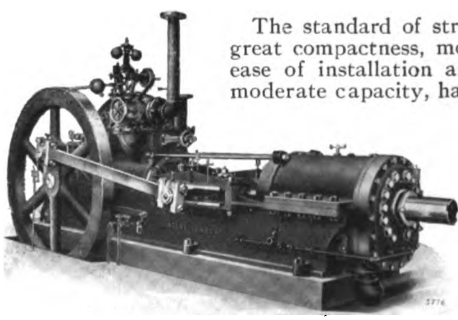
Small, compact compressors of straight line pattern, suitable for stationary or portable plants of small capacity: Simple steam cylinder with plain slide valve: Single stage air cylinder with complete water jacketing: Air valves of approved design and good economy: A type having a wide field where good "all-round" results and steady reliability are desirable: Pamphlet 3009.

Rand Class "RC-1"

Simple. plain, positive, straight line compressors of rugged design and good economy: Simple steam cylinder and single stage jacketed air cylinder: Suitable for plants of small or moderate capacity, semi-permanent or temporary in character, under conditions of hard service and ordinary unskilled attendance: Solid, compact, powerful and dependable machines, reasonable in fuel cost and maintenance.

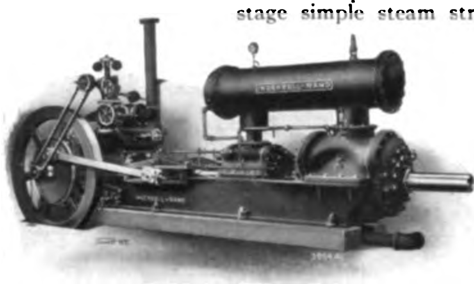


Ingersoll Class "A-1"



The standard of straight line types, embodying great compactness, moderate cost, simplicity, and ease of installation and operation: For plants of moderate capacity, hard service, ordinary care and semi-permanent character, for mines, quarries, and shops: Adjustable cut-off steam valves, except on smaller sizes which have plain slide valves: Single stage air cylinder with complete jacketing: Air valves of highest efficiency, giving strictly high-grade performance: Pamphlet 3002.

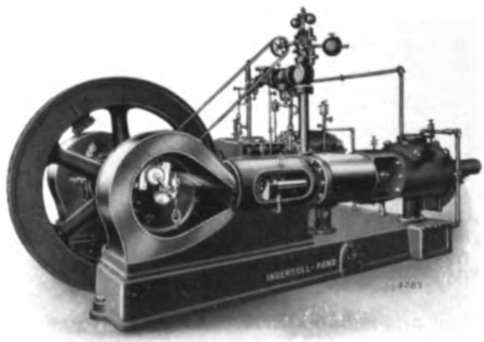
Ingersoll Class "AA-2"



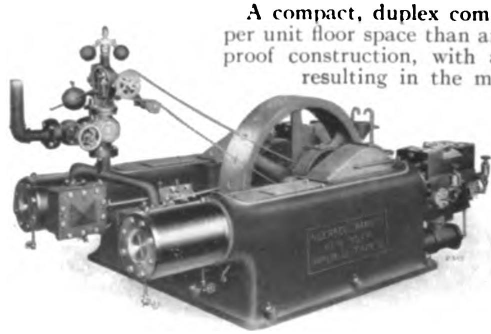
A development of the original "A" type into a two stage simple steam straight line compressor: Notable improvements in important details, making this a new standard of straight line economy, with all the efficiency of compound compression combined with the simplicity, compactness and "unit" quality of the straight line type: Balanced adjustable cut-off steam valves: Air cylinders and intercooler realizing the best two stage ideals: Pamphlet 3003.

Ingersoll Class "HH"

A powerful duplex machine, distinguished by its heavy subbase: Simple or compound, condensing or non-condensing steam cylinders, with Meyer valve gear: Air cylinders duplex or two stage, with complete jacketing and perfect intercooling: A solid, rugged, simple machine, high-class in every detail of design and construction: A "unit" construction, self-contained and automatic in operation: Deservedly one of the most popular types in every class of service: Pamphlet 3018.

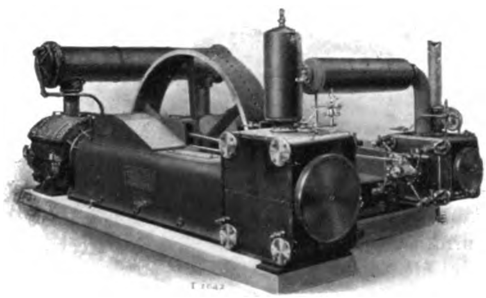


Rand "Imperial X"



A compact, duplex compressor with a larger capacity per unit floor space than any other type: Enclosed, dust-proof construction, with automatic "flood" lubrication resulting in the minimum of friction and wear: Steam and air cylinders simple duplex or cross-compound: Completely accessible and as easily installed and maintained as the simplest straight line type: A compressor of great staying power, automatic in operation: Preeminently the machine for hard, "knock-about" service: Pamphlet 3011.

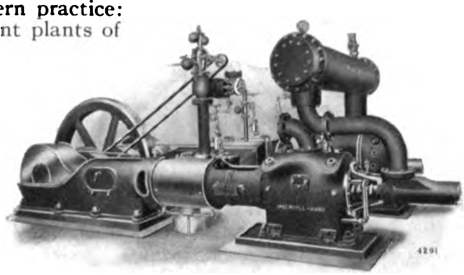
Rand "Imperial-Corliss XC"



A development of the original "Imperial" type, to secure Corliss steam economy at high speeds: A high-duty machine in the best sense, with modified Corliss steam valves, Rand-Corliss air inlet valves and "Imperial" Direct Lift discharge valves: A superb type, newly designed throughout for high sustained economy at every point: Enclosed "flood" lubrication of every wearing part: A compressor always to be relied upon for high-grade results: Pamphlet 3013.

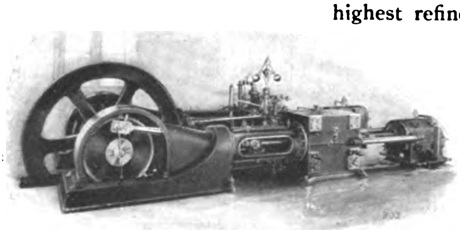
Ingersoll Class "O"

A duplex compressor new in every detail and representing the most modern practice: For semi-permanent or permanent plants of moderate or large capacity, where the best results are to be maintained: Enclosed, dust-proof construction, with a system of "flood" lubrication for every wearing surface: An unusually heavy, massive design throughout, intended for the very best performance under all conditions of operation: The latest embodiment of thirty-eight years of compressor building: Pamphlet 3006.

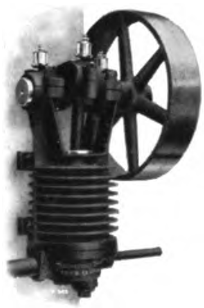


Ingersoll-Rand "Corliss"

A Corliss engine-driven compressor of the highest refinement of design, preeminent in its class for large permanent or semi-permanent plants where the highest attainable economy is essential: The machine which delivers compressed air at the minimum cost, combining the best steam engine and compressor practice, for results covering not months merely, but years of high-duty performance: Pamphlet 3005.



Standard Power Driven Types

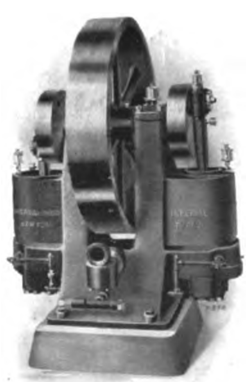


Rand "Imperial Baby"

A sturdy little machine representing the acme of simplicity: Single-acting, air-cooled cylinder, giving good economy at the moderate pressures and intermittent service for which this type is intended: Ordinarily built with a single belt wheel and bolted to a wall or post, but sometimes furnished with special frame for electric gear drive: Pamphlet 3021.

Rand "Imperial Junior"

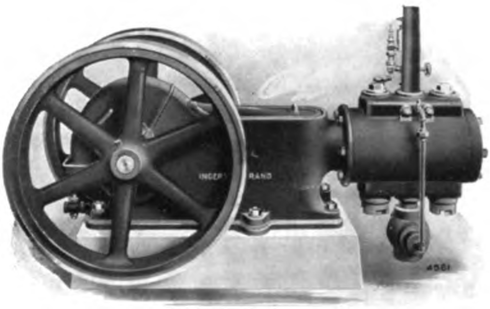
A vertical, single-cylinder, single-acting compressor of the same capacity as the "Imperial Baby," but with a water-jacketed air cylinder: Built either with a subbase, with lugs for bolting to wall or post, or with a special frame for gear drive from a motor: A sturdy and efficient little machine for purposes where a limited capacity and ordinary pressure are required, with a steady demand: Pamphlet 3021.



Rand "Imperial XI"

A duplex, vertical, single-acting machine, built for single or two stage compression: Water-jacketed air cylinders and air valves of correct design, giving good economy and steady reliability: A very compact design, requiring the minimum of floor space and accessible on every side: Especially adapted to shops, mills, foundries, factories and all installations of small capacity: A solid, powerful construction, with the minimum of parts and bearings, and a sturdy dependability: Pamphlet 3021.

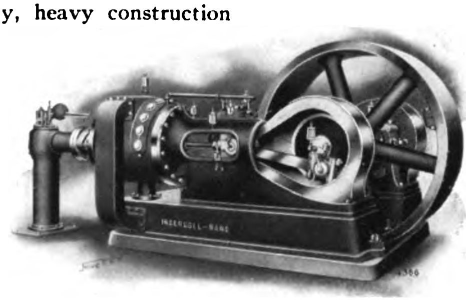
Ingersoll Class "NE-1"



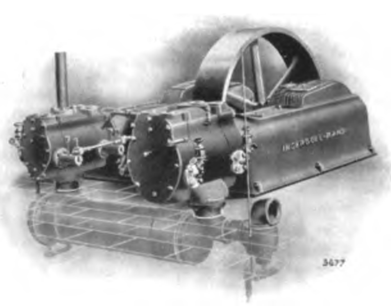
A straight line model representing the best design and construction applied to small machines: An enclosed construction excluding dirt and grit, with "splash" lubrication of every important bearing: Single stage air cylinder, with every provision for economical simple compression: Simple and compact, efficient and thoroughly well-built, adapted to a wide variety of uses: Suitable for small stationary or portable plants, driven from any source of power: Pamphlet 3110.

Ingersoll Class "JJ"

A modification of the "HH" steam-driven type for power drive, retaining the distinctive subbase and "unit" construction: Marked by extreme simplicity, heavy construction powerful design, self-contained character, and a very high mechanical and compression efficiency: Adapted for driving from any prime mover, by any of the approved methods of connection: Air end duplex or two stage: A very popular type enjoying an increasing demand: Pamphlet 3019.

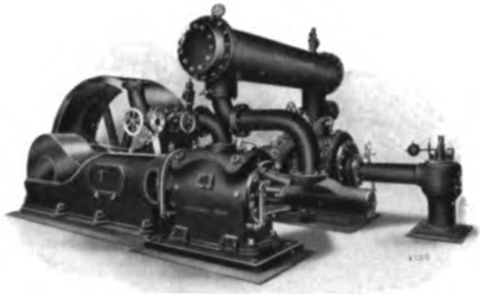


Rand "Imperial XB"



A power-driven machine with the characteristic features of the "Imperial X" pattern, with a heavy subbase and a central fly-wheel: Automatically self-regulating, with a "flood" system of lubrication throughout and an enclosed construction: A very large capacity combined with very small dimensions, adapting it to locations with limited floor space: A structure liberally designed throughout for the requirements of power drive from any source and by any method of connection: Pamphlet 3012.

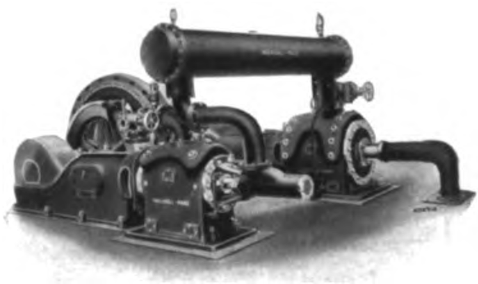
Ingersoll Class "PB"



A power driven modification of the Class "O" steam driven type, for belt or rope drive from an independent prime mover, with every refinement looking to economical compression: Cylinders completely jacketed, intercooler of unusual proportions, air valves designed for the best possible efficiency: Wearing parts protected from dust and dirt by the enclosed construction and automatically lubricated by a "flood" oiling system: Pamphlet 3007.

Ingersoll Class "PE"

Another modified "O" type, exclusively intended for direct shaft drive by an electric motor either direct or alternating current, induction or synchronous type: the "Corliss" of the power driven class, embodying every refinement for power drive at minimum operating cost: Special devices for starting and regulating, adapted to the high-class work for which the type is intended: A splendid machine of the most advanced construction: Pamphlet 3008.



High Pressure Compressors

Modifications of various types previously outlined, designed for pneumatic haulage, gas or air storage purposes, experimental use, etc.: As reliable, efficient, and thoroughly standardized for this exacting class of work as the machines for lower pressures: Characterized by notable improvements and distinctive devices which place them in the most advanced position: Pamphlet 3014.

The Ingersoll-Rand Co.

Information Needed for Estimate on Air Lift Pumping Outfit

1. How many wells are to be pumped?..................

2. Entire depth:

No. 1..........ft. No. 2..........ft. No. 3..........ft. No. 4..........ft.

3. Inside diameter casing at top:

No. 1..........in. No. 2..........in. No. 3..........in. No. 4..........in.

4. If inside diameter is reduced, state at what depth below surface and to what diameter:

No. 1 at.......ft. No. 2 at.......ft. No. 3 at.......ft. No. 4 at.......ft.

to.......in. to.......in. to.......in. to.......in.

5. If any further reduction in diameters state fully below:

No. 1..

No. 2..

No. 3..

No. 4..

6. To what depth is well cased?

No. 1..........ft. No. 2..........ft. No. 3..........ft. No. 4..........ft.

Is casing air tight?............... If not, where is leak?...............

7. What make, length, diameter and depth to strainers?

No. 1.................. Bottom open or closed?.................

No. 2.................. Bottom open or closed?.................

No. 3.................. Bottom open or closed?.................

No. 4.................. Bottom open or closed?.................

8. How far below the surface does the water stand when not pumping?

No. 1..........ft. No. 2..........ft. No. 3..........ft. No. 4..........ft.

No. 1........gals. No. 2........gals. No. 3........gals. No. 4........gals.

10. What natural head or pressure do they have at surface when closed?

No. 1..........lb. No. 2..........lb. No. 3..........lb. No. 4........lb.

11. If wells have been pumped, at how many gallons per minute?

No. 1........gals. No. 2........gals. No. 3........gals. No. 4........gals.

12. How far below the surface did the water level fall when giving the above quantity?

No. 1..........ft. No. 2..........ft. No. 3..........ft. No. 4..........ft.

13. At what depth below the surface is the water obtained?

No. 1..........ft. No. 2..........ft. No. 3..........ft. No. 4..........ft.

14. Was the pump used a suction, deep well or air lift?......................

15. State all cylinder diameters, length of stroke, speed, and WHETHER DUPLEX or Single: ....

16. How far above the ground surface must the water be raised?............ft.

17. How far horizontally from the well is it to be discharged?

No. 1..........ft. No. 2..........ft. No. 3..........ft. No. 4..........ft.

18. What horse-power of boiler can you spare and what steam pressure do you carry?......................H.P..................lbs.

19. Can you use a belt-driven Air Compressor?..............................

H.P. available........................

20. What is the source of water supply; sand, gravel or rock?................

21. How many gallons per minute do you require?........................gals.

22. When there are more than one well please make sketch showing location and distances, and write any other remarks on back of this sheet.

Name.................................

Address..

Date..........................

CAMERON STEAM PUMPS

Ingersoll-Rand Company

11 Broadway, New York

TRADE MARK
REG. U.S. PAT. OFF.

Form No. 7004 **February, 1911**

THE CAMERON policy, steadily pursued ever since the inception of the business, has been to build the very best pump that the best of material and most skillful workmanship can produce, and time has, we think, demonstrated the wisdom of refusing to sacrifice, on the score of cheapness, the high quality of workmanship and material, but more especially the excellence of design, which renders the CAMERON durable beyond all others, and its few working parts readily and easily replaceable. Moreover, we believe, in buying a CAMERON you will save money in cost of repairs.

Besides other sterling qualities, the three points of excellence peculiar to the CAMERON are: First, Simplicity; second, Durability; third, Entire absence of outside valve gear or moving parts.

SIMPLICITY—The CAMERON pump has fewer working parts than any other steam pump made.

DURABILITY—The steam mechanism consists of four stout pieces only, none of them delicate, intricate or exposed to injury. The operation of this mechanism is such that—

While under full pressure of steam, the suction pipe may be lifted out of the water and the pump allowed to run away or race as fast as steam will drive it, without danger of the piston striking the heads or any injury to the pump. The advantage of this can scarcely be exaggerated, since under most conditions any pump is liable to have its supply of water cut off unexpectedly. They are made stronger and heavier than other pumps of the same capacity.

ABSENCE OF OUTSIDE VALVE GEAR—The steam valve movement works in line with the piston rod without the intervention of arms or

levers. The pump can, therefore, be run, without danger of breaking, at a greater speed than any pump employing an outside valve movement. There are no rods to become bent, broken or get out of alignment, no tappet bars, rollers or clamps to be adjusted.

The cylinders are made of hard, close grained iron, and are of such thickness as to permit reboring. All pumps, unless otherwise ordered, are fitted with valve seats of best composition and arranged to handle fresh cold water. If required to handle feed water of high temperature, they will be supplied with the proper valves and packing.

There have been placed on the market more or less recently several pumps with inside steam mechanism and valve gear. Examination will show that they lack the simplicity claimed for them. Some of these pumps, sold for boiler feeding, are equipped with deflecting valves for turning their exhaust steam into the suction. The oil or any lubricant from the cylinder thus carried in with the feed water is highly injurious to the boiler, and the practice is severely condemned by boiler insurance inspectors. On the other hand, the steam mechanism of CAMERON pumps is entirely without minute steam ports, grooves, packing rings or other complicated devices, and the pumps themselves are especially noted for their ability to perform exacting service and work under trying conditions. They can stand almost any amount of rough usage, and we find they often do stand a great deal of abuse.

There being no dead center the pump will always start at any point of the stroke, and can be run so slowly that the eye can hardly detect the motion of the piston rod.

The pump can be completely taken apart without disconnecting any of the pipes.

Every pump sold by us is thoroughly tested before leaving the works, and is fully guaranteed to be exempt from any faulty construction and from defects of material or workmanship. Its satisfactory operation is also guaranteed on condition that it is properly set up, reasonably cared for and used for a service and capacity corresponding to its proportions and design.

Many inaccurate statements and unwarranted claims have been advanced in behalf of duplex pumps. Several makers go as far as to state that their duplex pumps are "double the capacity of single pumps of the same diameter and stroke," a misrepresentation which we can hardly let pass unnoticed. In the first place a CAMERON pump can be run safely and comfortably at a speed that would knock a duplex pump with its lever arm contrivances all to pieces. But even at a low speed duplex pumps seldom attain even their theoretical capacities, and the reason for this is neither mysterious nor difficult of comprehension. In all duplex pumps each steam piston is controlled and reversed by a connection with the opposite piston rod. Since it is beyond human ingenuity to pack two machines so that friction will be equal, it follows that one piston must move more sluggishly than the other, and this piston is constantly interrupted and reversed before it has a chance to complete its stroke. One pump is constantly short stroking.

A CAMERON pump cannot reverse until it has completed its full, honest stroke.

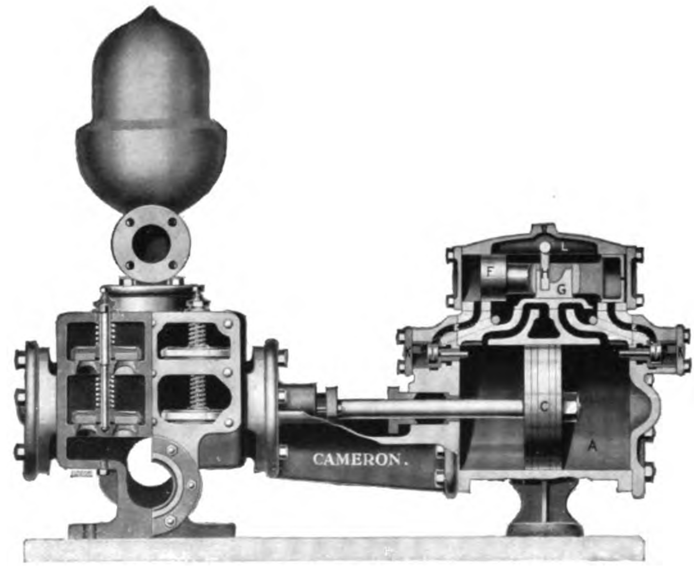
A CAMERON pump can be run continuously and without detriment at greater speed than any duplex pump made.

For two reasons duplex pumps are prodigally extravagant in the use of steam. First, because of the wasted clearance of steam in the cylinder whose piston is not travelling its full stroke. Second, because duplex pumps have double the number of ports, and steam spent in filling ports is steam wasted.

A duplex pump has more than double the number of parts to keep in repair, and when any one gives out the whole machine is crippled.

In nearly all duplex plunger pumps sold so cheaply and cheerfully for boiler feeding and other purposes, there is no possible way of compensating for wear—the more the water plunger wears the more churning and less pumping is done. Of course, the "parts can be renewed" —the oftener, the more there is in it for the maker.

Every CAMERON pump is packed to compensate for wear.



All single, direct-acting pumps make use of an auxiliary plunger to carry the main slide valve, which gives steam to the main piston. By means of various devices steam pressure is made to drive this auxiliary plunger backward and forward. In the CAMERON pump the plunger is reversed by means of two plain tappet valves, and the entire mechanism thus consists of four stout pieces only, all working in direct line with the main piston. Simple and without delicate parts, it is the only inside valve gear that is absolutely reliable.

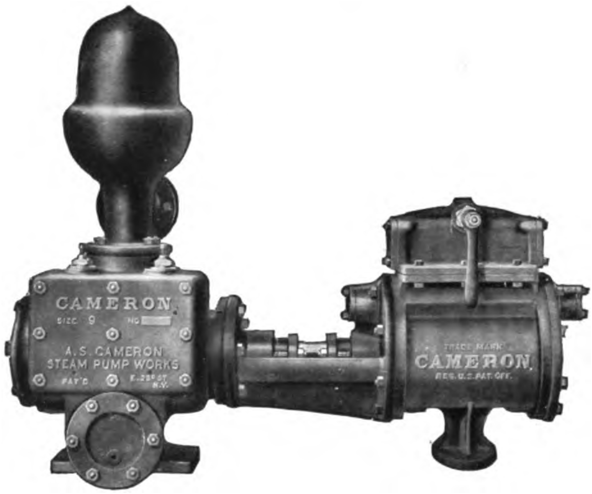
EXPLANATION

A is the steam cylinder; *C,* the piston; *L,* the steam chest; *F,* the chest plunger, the right-hand end of which is shown in section; *G,* the slide valve; *H,* a lever, by means of which the steam chest plunger *F* may be reversed by hand when expedient; *II,* are reversing valves; *KK* are the reversing valve chamber bonnets, and *EE* are exhaust ports leading from the ends of steam chest direct to the main exhaust and closed by the reversing valves *II*.

OPERATION

C, the piston, is driven by steam admitted under the slide valve *G*, which, as it is shifted backward and forward alternately connects opposite ends of the cylinder *A* with the live steam pipe and exhaust. This slide valve *G* is shifted by the auxiliary plunger *F*; *F* is hollow at the ends, which are filled with steam, and this, issuing through a hole in each end, fills the spaces between it and the heads of the steam chest in which it works. Pressure being equal at each end, this plunger *F*, under ordinary conditions, is balanced and motionless; but when the main piston *C* has traveled far enough to strike and open the reverse valve *I*, the steam exhausts through the port *E* from behind that end of the plunger *F*, which immediately shifts accordingly and carries with it the slide valve *G*, thus reversing the pump. No matter how fast the piston may be traveling, it must instantly reverse on touching the valve *I*. In its movement the plunger *F* acts as a slide valve to close the port *E*, and is cushioned on the confined steam between the ports and steam chest cover. The reverse valves *II* are closed as soon as the piston *C* leaves them by a constant pressure of steam behind them conveyed direct from steam chest through the ports shown by dotted lines.

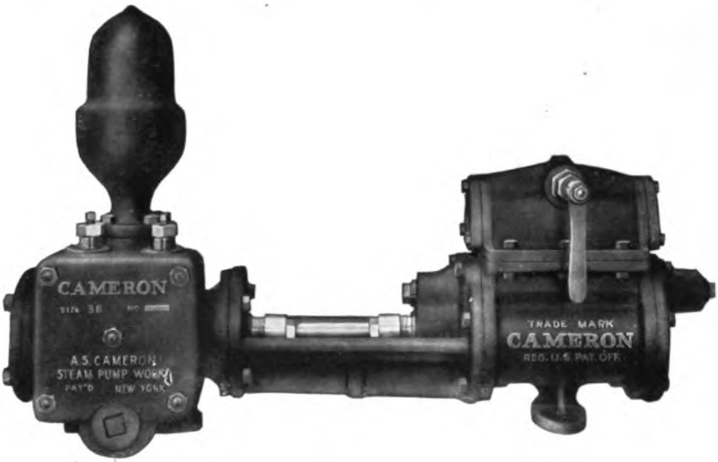
The illustration on the opposite page shows the CAMERON valve chest and arrangement of water valves. The superiority of this valve chest lies in its accessibility. By simply removing one bonnet or cover, the whole interior with every valve is plainly visible, turned inside out so to speak, and not a speck of anything that may have lodged there can escape detection. The shelves or decks are bored out tapering, and the brass seats forced in. They can thus be readily taken out and renewed at any time. Each stem holds two valves, with their springs one above the other, so that by simply unscrewing one plug, and pulling up the stem, both are released. It will be noticed that the CAMERON valve chest is placed close to the ground and beside the water piston, instead of above it as in other makes. The valves are therefore just so much nearer the water, and the suction lift is reduced accordingly. Every pump has two suction openings, one on each side, and the discharge opening can be turned in any direction desired.



Regular Pattern Piston Pump

The first seven sizes of the regular pattern pump are not furnished with the hand lever attachment unless it is specified in the order. Either iron water cylinder and steel piston rod or water cylinder lining, piston and piston rod of composition can be supplied if desired. The above illustration shows sizes 5 to 10. This pump is also made in larger sizes, which are the same as shown above except that they have a series of water valves.

Code Word	Size Number	Price with Iron Water Cylinder and Steel Piston Rod	Price with Water Cylinder Lining Piston and Piston Rod of Composition	Diameter of Steam Cylinder, Inches	Diameter of Water Cylinder, Inches	Stroke of Piston, Inches	Capacity at Ordinary Speed, per Minute. Gallons	Steam Pipe	Exhaust Pipe	Suction Pipe	Discharge Pipe	Floor Space, Inches	Weight, lbs.
Zaaby	0	$80	$85	3½	2	4	8	⅜	½	1¼	1	32x9	136
Zaadu	1	120	125	4	2	6	12	⅜	½	1¼	1	40x10	210
Zaaes	2	140	150	5	2½	6	18	½	¾	1½	1¼	40x11	254
Zaago	3	165	175	6	3	7	28	¾	1	2	1½	47x13	418
Zaahm	3a	185	200	6	3½	7	38	¾	1	2½	2	47x15	435
Zaaik	4	210	225	7	3½	7	38	¾	1	2½	2	47x15	459
Zaaji	4a	235	250	7	4	7	50	¾	1	2½	2	51x16	457
Zaalt	5	275	290	7	3½	12	50	1	1½	3	2½	58x17	820
Zaamc	5b	325	350	7	5	13	100	1	1½	4	3	63x20	1117
Zaanz	6	325	340	8	4	12	65	1	1½	3	2½	58x18	864
Zaaox	6a	350	375	8	5	13	100	1	1½	4	3	63x20	1160
Zaarp	7	375	400	10	5	13	100	1¼	2	4	3	64x21	1345
Zaasn	8	400	425	10	6	13	150	1¼	2	4	3½	64x21	1411
Zaatl	9	470	520	12	7	13	200	1½	2½	5	4	66x24	1928
Zaauj	10a	540	575	14	8	13	261	2	3	5	5	73x26	2548

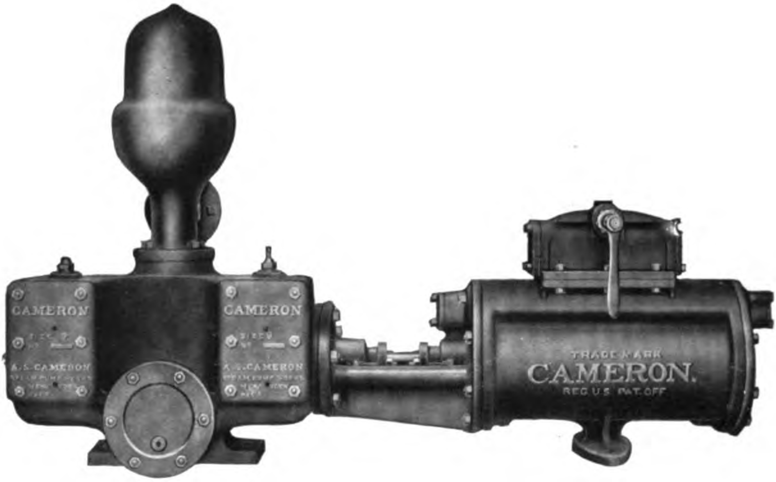


Regular Boiler Feed Pattern

The main difficulty met with in fixing on the proper size of pump to recommend is that the horse-power of the boiler for which the pump is required, is about all the information furnished. The expression "horse-power," as applied to boilers, is a very indefinite term; what should be given, if possible, is the quantity of feed water required, and a pump which will supply this quantity at about one-half its rated capacity at ordinary speed will be right for cold water, and say one-third speed for hot water.

In feeding hot water the pump should be placed below the source of supply. Sizes 0 to 3b are made as illustrated on this page.

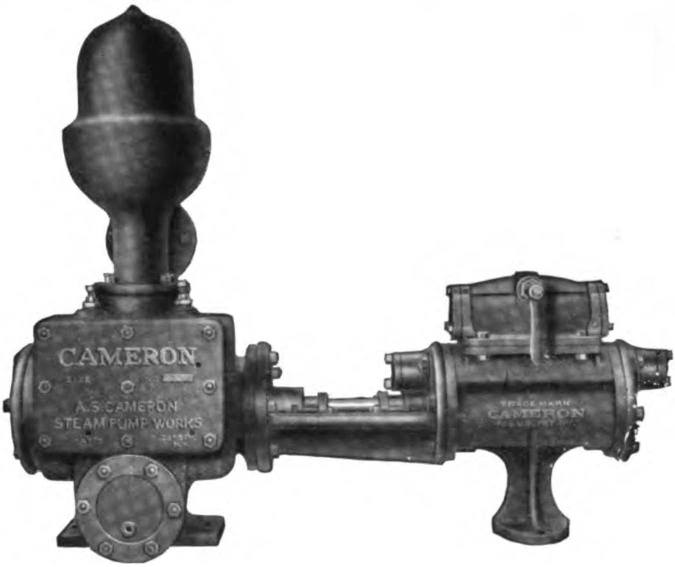
Code Word	Size Number	Price with Iron Water Cylinder and Steel Piston Rod	Price with Water Cylinder Lining Piston and Piston Rod of Composition	Diameter of Steam Cylinder, Inches	Diameter of Water Cylinder, Inches	Stroke of Piston, Inches	Capacity at Ordinary Speed, per Minute, Gallons	Boilers, in Horse Power, they will supply at Moderate Speed Based on 30 lbs. of Water per Horse Power per Hour	Steam Pipe	Exhaust Pipe	Suction Pipe	Discharge Pipe	Floor Space, Inches	Weight, lbs.
Zabna	0	$80	$85	3½	2	4	8	40	⅜	½	1¼	1	32x9	136
Zaboy	1	120	125	4	2	6	12	60	⅜	½	1¼	1	40x10	210
Zabso	2	140	150	5	2½	6	18	90	½	¾	1½	1¼	40x11	254
Zabuk	2a	150	165	5	3	7	28	140	½	¾	2	1½	47x12	347
Zabvi	2b	160	170	5	3½	7	38	190	½	¾	2½	2	47x14	355
Zabxe	3b	210	225	6	4	7	50	250	¾	1	2½	2	47x14	422
Zabyc	3c	210	225	6	3½	12	50	325	¾	1	3	2½	58x17	520
Zacac	3d	230	245	6	4	12	65	425	¾	1	3	2½	58x17	525
Zacba	5a	280	310	7	4½	12	80	525	¾	1	3	2½	58x18	725
Zaccy	5b	325	350	7	5	13	100	670	1	1½	4	3	63x20	1117
Zaceu		375	400	8	6	13	150	1000	1	1½	4	3½	64x21	1202
Zacho	....	445	490	10	7	13	200	1325	1¼	2	5	4	66x24	1770
Zacim	....	500	530	12	8	13	261	1725	1½	2½	5	5	73x26	2010
Zacki		....	....	14	9	18	330	2200	2	3	6	5	81x30	3125



Long Stroke Piston Pump

This type is especially adapted for rolling mills, blast furnaces, sugar or oil refineries, and other situations where continuous pumping is required. Its piston stroke being nearly twice the length of that of the "regular" type, all working parts, except pistons and rod, are brought into action only half the number of times for the same piston speed; wear and tear is reduced and the life of the pump prolonged accordingly. Valve chests are placed at both ends of the water cylinder, thus making the water passages short and direct.

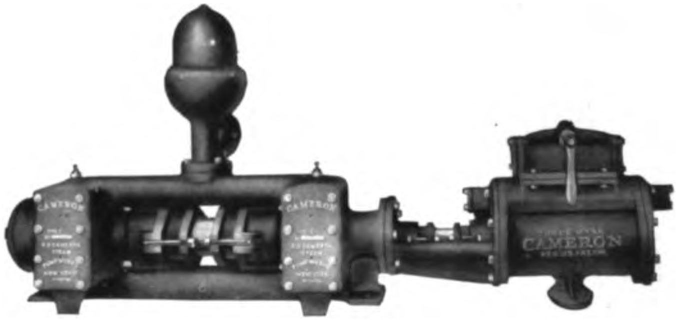
Code Word	Size Number	Price with Iron Water Cylinder and Steel Piston Rod	Price with Water Cylinder Lining Piston and Piston Rod of Composition	Diameter of Steam Cylinder, Inches	Diameter of Water Cylinder, Inches	Stroke of Piston, Inches	Capacity per Stroke, Gallons	Capacity at Ordinary Speed, per Minute, Gallons	Steam Pipe	Exhaust Pipe	Suction Pipe	Discharge Pipe	Length over all, Inches	Height over all, Inches	Width over all, Inches	Weight, lbs.
Zadoa	7	$450	$500	10	5	25	2.12	115	1¼	2	5	3½	87	45	22	1687
Zadpy	8	475	525	10	6	25	3.0	170	1¼	2	5	3½	87	45	22	1741
Zadto	9	550	600	12	7	25	4.17	225	1½	2½	6	4	90	57	24	2345
Zadum	10	..	..	14	9	33	9.08	350	2	3	8	6	118	70	30	4235
Zadwi	11	..	..	16	10½	33	12.37	500	2½	4	10	8	122	74	36	5732
Zadye	12	..	....	18	12	38	18.60	660	3	4	12	10	142	92	42	7830



Regular Light Service Pattern

This pump is adapted for filling tanks, irrigating and light duty generally, on railways, in factories, and for situations where a considerable quantity of water is to be lifted to a limited elevation. It is not designed for mining work, nor to force water against heavy lifts. In light service, pressure on the valves being low, the pump can therefore be run faster, thus obtaining a greater capacity than given in list.

Code Word	Price with Iron Water Cylinder and Steel Piston Rod	Price with Water Cylinder Lining Piston and Piston Rod of Composition	Diameter of Steam Cylinder, Inches	Diameter of Water Cylinder, Inches	Stroke of Piston, Inches	Capacity at Ordinary Speed, per Minute, Gallons	Steam Pipe	Exhaust Pipe	Suction Pipe	Discharge Pipe	Weight, lbs.
Zaeew	$140	$150	4	3	7	28	3/8	1/2	2	1 1/2	335
Zaegt	150	160	4	3 1/2	7	38	3/8	1/2	2 1/2	2	346
Zaehr	160	170	5	3 1/2	7	38	1/2	3/4	2 1/2	2	358
Zaeio	160	170	4	4	7	50	3/8	1/2	2 1/2	2	345
Zaejm	170	180	5	4	7	50	1/2	3/4	2 1/2	2	360
Zaekk	210	225	5	5	7	80	1/2	3/4	3	2 1/2	553
Zaemg	230	250	6	5	7	80	3/4	1	3	2 1/2	628
Zaend	275	300	6	6	7	115	3/4	1	4	3	800
Zaeob	285	310	7	6	7	115	3/4	1	4	3	824
Zaepz	380	435	7	7	13	200	1	1 1/2	5	4	1540
Zaeru	400	450	8	7	13	200	1	1 1/2	5	4	1575
Zaess	425	465	9	7	13	200	1	1 1/2	5	4	1680
Zaeun	445	490	10	7	13	200	1 1/4	2	5	4	1800
Zaewj	410	450	7	8	13	261	1	1 1/2	5	5	1630
Zaexh	420	460	8	8	13	261	1	1 1/2	5	5	1660
Zaeyt	480	550	8	9	13	330	1	1 1/2	6	5	2050

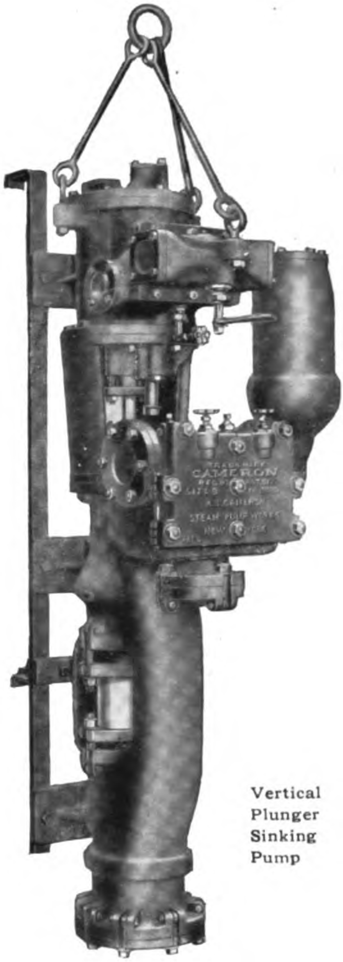


Outside Packed Plunger Pump

This pump is especially adapted for station duty in mines, and is far more durable than a piston pump for handling gritty water.

There are no wearing parts in the water end except the packing in the stuffing boxes, which can be instantly tightened up from the outside. Since the plunger works in loose sleeves, the pump barrel cannot be cut or worn by grit or sand, and the stuffing boxes are placed in the center, so that there is no tendency for the plunger to sag. It is more compact than any other make of plunger pump, and has no outside rods or cross-heads. It is also adapted for feeding boilers under heavy pressure.

Code Word	Size	Price with Iron Plunger and Steel Piston Rod	Price with Composition Plunger and Piston Rod	Diameter of Steam Cylinder, Inches	Diameter of Plunger, Inches	Stroke of Piston, Inches	Capacity at Ordinary Speed, per Minute, Gallons	Boilers, in Horse Power they will supply at moderate Speed, based on 30 pounds of Water, per Horse Power, per Hour	Steam Pipe	Exhaust Pipe	Suction Pipe	Discharge Pipe	Floor Space, Inches	Weight, lbs.
Zaihv	A	$125	$150	4	2	6	12	60	3/8	½	1¼	1	53x10	283
Zaiit	B	220	250	6	3	7	28	140	¾	1	2	1½	59x13	551
Zaiko	B-B	270	300	7	3½	7	38	190	¾	1	2	1½	60x15	600
Zailb		325	375	7	3½	12	50	325	1	1½	3	2½	82x18	1200
Zaimk	C	375	425	8	4	12	65	425	1	1½	3	2½	82x18	1291
Zainh	D	475	550	10	5	13	100	670	1¼	2	4	3	91x23	1937
Zaiof	..	515	600	12	5	13	100	670	1½	2½	4	3	91x25	2173
Zaipd	...	500	575	8	6	13	150	1000	1	1½	4	3½	94x23	1960
Zairy	....	525	600	10	6	13	150	1000	1¼	2	4	3½	96x24	2150
Zaitu	E	625	750	12	6	18	150	1000	1½	2½	5	4	114x25	2995
Zaius	...	700	825	14	6	18	150	1000	2	3	5	4	126x27	3517
Zaivp	...	750	925	16	6	18	150	1000	2½	4	5	4	130x28	4000
Zaiwn	...	585	650	10	7	13	200	1325	1¼	2	5	4	99x26	2575
Zaiyj	E-E	625	700	12	7	13	200	1325	1½	2½	5	4	99x27	2735
Zaizm	....	650	750	12	7	18	200	1325	1½	2½	5	4	114x27	2970
Zajaj	...	675	775	14	7	13	200	1325	2	3	5	4	103x27	3135
Zajeb	....	700	800	14	7	18	200	1325	2	3	5	4	126x28	3372



Vertical Plunger Sinking Pump

This is the most successful sinking pump that has ever been placed on the market. Any steam pump that is to be used in sinking a mine shaft must be strong, certain in operation, capable of handling gritty water, require little attention, and above all, be able to stand the roughest kind of usage without sustaining injury.

This pump retains all the advantages of the horizontal types of Cameron pumps besides having several features of importance for a sinking pump. There are no exposed parts liable to breakage; it takes up less room in the shaft than any other make of pump; it cannot be damaged by collision with the side walls; it is not likely to be injured by blasts; and it is designed and intended to handle gritty water.

Code Word	Size Number	Price with Iron Plunger and Steel Piston Rod	Diameter of Steam Cylinder, Inches	Diameter of Plunger, Inches	Stroke of Piston, Inches	Capacity at Ordinary Speed, per Minute, Gallons	Steam Pipe	Exhaust Pipe	Suction Pipe	Discharge Pipe	Space Occupied in Shaft, Inches	Weight, lbs.
Zakec	5	$350	7	3½	12	50	1	1½	2½	2	24x24	1410
Zakiv	6	400	8	4	12	65	1	1½	3	2½	25x25	1435
Zakoh	7	500	10	5	13	100	1¼	2	4	3	31x30	2285
Zakra		575	12	5	13	100	1½	2½	4	3	32x33	2620
Zaksy	8	525	10	6	13	150	1¼	2	4	3½	31x31	2290
Zakyl	9a	575	12	6	13	150	1½	2½	4	3½	32x33	2545
Zakzo	..	675	14	6	13	150	2	3	4	3½	40x35	3600
Zalal	9	625	12	7	13	200	1½	2½	5	4	34x33	3400
Zalch	9b	675	14	7	13	200	2	3	5	4	40x35	3850
Zaled		750	16	7	16	200	2½	4	5	4	42x40	4650
Zalga		850	18	7	16	200	3	4	5	4	42x45	5000
Zalhy	10	725	14	8	13	261	2	3	5	5	40x38	4150
Zaliw	11	800	16	8	16	261	2½	4	5	5	42x40	4750
Zalju		900	16	9	16	330	2½	4	6	5	42x45	5220
Zalks	12	1000	18	9	16	330	3	4	6	5	42x45	5575

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